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ERRATA.

Page 195, 4th line from top, for southwest read *northwest.*

Page 401, lines 16, 22 and 24 from top, for glycogen acid read *glycogenic* acid.

Page 482, line 5 from top, for Powell read *Howell.*

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CONTENTS OF VOLUME XI.

NUMBER LXI.

NUMBER LXII.

SCIENTIFIC INTELLIGENCE.

NUMBER LXIII.

SCIENTIFIC INTELLIGENCE.

NUMBER LXIV.

SCIENTIFIC INTELLIGENCE.

NUMBER LXV.

SCIENTIFIC INTELLIGENCE.

NUMBER LXVI.

SCIENTIFIC INTELLIGENCE.

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JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. I.—*Contributions to Meteorology, being Results derived from an examination of the United States Weather Maps and from other sources*; by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Fourth paper. With Plate.

[Read before the National Academy of Sciences, Philadelphia, Nov. 2, 1875.]

Movement of Areas of high barometer.

HAVING determined the average direction and velocity of movement of areas of low barometer within the limits of the United States, I desired to make a similar determination respecting areas of high barometer. As I have in my possession only one Weather Map for each day, I have frequently found it difficult to follow the course of areas of high barometer from day to day, and have therefore confined my comparison to the monthly charts published by the U. S. chief signal officer. Among these I found three charts which gave the tracks of areas of high barometer for a month each, viz: Aug., 1873, Dec., 1874, and Jan., 1875. The following are the average courses and velocities of the areas of high barometer for these months:

MONTHS.	Course.	Velocity. Miles per hour.	High minus Low.	
			Course.	Velocity.
January, ...	E. 2° N.	21·6	7° S.	−5·7
August, ...	E. 41 S.	18·9	46 S.	+0·5
December, ...	E. 18 S.	28·5	25 S.	−0·8
Mean	E. 12 S.	24·8	21 S.	−1·2

The lower line shows the averages for the three months, regard being had to the number of cases in each month. Comparing these results with those given in my last article for areas of low barometer (this Jour., vol. x, p. 5), we find that for each month the course of high barometer is more southerly than low barometer. These differences are shown in column fourth. Column fifth shows the differences in velocity for each month.

These observations indicate that while the average track of storms east of the Rocky Mountains, across the United States, is nine degrees to the north of east, areas of high barometer advance toward a point several degrees south of east, and with a velocity somewhat less than the former.

Monthly minima of temperature.

In a former article (this Jour., vol. ix, p. 7) I gave a table showing the lowest temperature observed at New Haven for each month during a period of three years, together with the height of the barometer, direction of the wind, and degree of cloudiness for the corresponding dates, and I expressed the opinion that these low temperatures are due in part to the descent of cold air within an area of high barometer. Inasmuch as some persons ascribe these low temperatures to a flow of air from a higher latitude, it has appeared to me that it would be instructive to study the same phenomenon at a locality where a current of air from a colder latitude is impossible; and such a locality must be found at the point of minimum temperature for the northern hemisphere. Now according to Dove's charts; during the winter months Jakutsk, in Siberia, lat. 62° 2′ N., is situated very near the center of greatest cold for the northern hemisphere. I have, therefore, sought for a complete meteorological journal at this station, and have found it in Middendorff's Sibirische Reise, Band I, pp. 28–49, extending from Sept., 1844, to June, 1846. The following table shows the results obtained for each month of this period.

Column first shows the date of the lowest temperature for each month; column second shows the lowest temperature for each month in degrees of Reaumur; column third shows the direction of the wind, and column fourth shows the force of the wind; column fifth shows whether the sky was clear or overcast; column sixth shows the height of the barometer expressed in Russian half lines; column seventh shows the mean height of the barometer for each month; column eighth shows how much the observed height of the barometer differed from the mean height expressed in English inches (one-half line=0·05 inch English).

From this table it will be seen that the monthly minima of temperature are almost entirely independent of the direction of

the wind. A northerly direction occurs 10 times; southerly, 6 times; easterly 7 times; and westerly, 5 times. In every instance (except one) these winds were faint, and generally *very faint.* In two-thirds of the cases the sky was entirely clear, and in only two cases was the sky entirely overcast. In three-fourths of the cases the barometer stood above its mean height.

Lowest temperature for each month at Jakutsk, Siberia, for the years 1844, 5 *and* 6.

Date of minimum.			Minimum temp'e.	Wind direction.	Wind force.	Face of sky.	Russian Half Lines. bar.	m'n bar	Differ. Eng. Inches.
1844,	Sept.	30	−3°·1	N. W.	very faint.	overcast.	597·9	594·2	+0·19
	Oct.	31	−26·4	Calm.		clear.	599·2	593·4	+0·29
	Nov.	29	−40·1	N. N. W.	very faint.	clear.	601·5	596·5	+0·25
	Dec.	18	−44·8	Calm.		partly clear.	595·1	601·2	−0·30
1845,	Jan.	16	−44·4	S. S. W.	very faint.	clear.	596·6	597·9	−0·06
	Feb.	6	−40·7	Calm.		clear.	601·3	599·1	+0·11
	March	7	−31·9	N.	very faint.	clear.	601·2	594·9	+0·31
	April	5	−20·5	S.	very faint.	clear.	601·9	592·4	+0·48
	May	13	− 7·8	W.	strong.	overcast.	591·8	589·6	+0·11
	June	9	− 1·3	E.	faint.	clear.	584·4	587·3	−0·14
	July	30	+ 4·9	N. E.	very faint.	clear	593·5	587·6	+0·30
	Aug.	21	− 0·7	S.	very faint.	clear.	589·6	588·7	+0·05
	Sept.	26	− 5·3	Calm.		partly clear.	596·2	594·2	+0·10
	Oct.	31	−25·5	N. E.	faint.	partly clear.	597·4	593·4	+0·20
	Nov.	23	−39·8	N.	very faint.	clear.	603·9	596·5	+0·37
	Dec.	25	−41·1	N. E.	very faint.	clear.	604·6	601·2	+0·17
1846,	Jan.	10	−41·9	N. N. E.	faint.	partly clear.	595·9	597·9	−0·10
	Feb.	2	−43·6	N. N. E.	faint.	partly clear.	596·1	599·1	−0·15
	Mar.	14	−28·0	S. E.	faint.	clear.	599·5	594·9	+0·23
	April	10	−16·8	S.	very faint.	clear.	596·0	592·4	+0·18
	May	3	−17·4	N.	faint.	clear.	596·3	589·6	+0·33
	June	9	+ 2·4	W. S. W.	faint.	mostly overcast.	582·4	587·3	−0·24

In all these particulars, except the direction of the wind, the phenomena at Jakutsk are quite similar to those observed at New Haven. So far as I have yet learned it is true universally that periods of unusual cold are generally accompanied by a barometer above the mean. Now it has been shown (this Jour., vol. ix, p. 2) that within areas of high barometer the motion of the air is *outward* from the center of this area, and therefore there must be a downward motion to supply the air flowing outward. In other words, it must be regarded as an observed fact that periods of unusual cold are generally accompanied by *a descent of air from the upper regions of the atmosphere.*

Influence of Winds on the temperature, moisture and pressure of the atmosphere.

In order to determine the influence of winds upon the temperature, etc., of the atmosphere, I selected the Meteorological observations made at Girard College, Philadelphia, from 1840

to 1845. A large sheet of paper was ruled with 16 vertical columns, and at the head of these columns were placed the letters N.; N.N.E.; N.E., etc., for the directions of the wind. I first took the observations for the three winter months, and beginning with Dec. 1, 1840, found that at the first observation the wind was N.W. The temperature at this observation was compared with the mean temperature of that month for the same hour, and the difference (with its algebraic sign) was placed in the column headed N.W. I proceeded in like manner with each succeeding observation during the winter months for the whole period of five years. The average of all the numbers in each column was taken and the results are shown in column second of the following table. These numbers clearly indicate that the coldest winds are from the neighborhood of the N.W., and the warmest winds from the neighborhood of the S.E. As, however, the progress of the numbers is somewhat irregular, I have taken the average of each successive three numbers in this column and placed the results in column third. These numbers show a remarkable regularity, indicating a minimum with a N.W. wind, and increasing thence uninterruptedly to a maximum with a S.E. wind, and thence decreasing uninterruptedly to the minimum. The entire range of the numbers in column third is 8·°46 Fahr., while the extreme range in column second is 10·°18.

Influence of winds on the temperature, moisture and pressure of the atmosphere.

Direction of wind.	Thermometer at Philadelphia. Fahrenheit.				Force of vapor at Philadelphia. Inches of mercury.				Barometer at Philadelphia. 29 inches plus.			
	Winter means.	Winter aver'd.	Sum'er means.	Sum'er aver'd.	Winter means.	Winter aver'd.	Sum'er means.	Sum'er aver'd.	Winter means.	Winter aver'd.	Sum'er means.	Sum'er aver'd
	°	°	°	°								
N.	−1·57	−1·53	−3·69	−3·23	−·007	−·005	−·096	−·085	1·039	1·005	·950	·933
N. N. E.	−0·45	−0·25	−2·78	−2·85	+·005	+·003	−·072	−·072	·986	1·013	·937	·956
N. E.	+1·28	+0·40	−2·07	−2·51	+·012	+·005	−·047	−·055	1·014	1·038	·980	·975
E. N. E.	+0·36	+1·00	−2·68	−2·21	−·003	+·011	−·046	−·040	1·113	1·033	1·008	1·001
E.	+1·37	+2·66	−1·87	−1·82	+·023	+·025	−·026	−·029	·973	1·018	1·014	1·018
E. S. E.	+6·26	+4·25	−0·90	−1·15	+·055	+·043	−·016	−·004	·967	·953	1·033	1·014
S. E.	+5·11	+5·94	−0·66	−0·24	+·051	+·060	+·031	+·023	·918	·913	·994	·978
S. S. E.	+6·46	+5·69	+0·83	+0·55	+·075	+·059	+·054	+·046	·857	·898	·906	·934
S.	+5·50	+5·00	+1·48	+1·68	+·052	+·054	+·052	+·057	·920	·889	·901	·917
S. S. W.	+3·05	+3·88	+2·72	+2·48	+·036	+·029	+·066	+·061	·891	·900	·943	·912
S. W.	+3·09	+2·47	+3·24	+2·51	+·029	+·029	+·066	+·056	·890	·885	·893	·906
W. S. W.	+1·26	+1·08	+1·57	+2·42	+·023	+·007	+·036	+·038	·874	·911	·882	·896
W.	−1·12	−1·19	+2·44	+1·60	−·032	−·016	+·012	+·005	·968	·923	·914	·881
W. N. W.	−3·72	−2·03	+0·80	+0·10	−·039	−·032	−·034	−·034	·926	·961	·846	·882
N. W.	−1·26	−2·52	−2·94	−1·79	−·025	−·025	−·081	−·067	·989	·968	·887	·882
N. N. W.	−2·57	−1·80	−3·22	−3·28	−·012	−·015	−·086	−·088	·989	1·006	·912	·916

I proceeded in a similar manner with the observations for the three summer months and the results are shown in column

fourth. The average of each successive three numbers in this column was taken and the results are shown in column fifth.

In order to determine the influence of the winds on the moisture of the air I took the observations of the force of vapor (expressed in inches of mercury) and compared each observation with the mean force for that month, and the given hour. The results for the three winter months are shown in column sixth of the preceding table, and the averaged numbers are shown in column seventh. The results for the three summer months, obtained in like manner, are shown in columns eighth and ninth.

In order to determine the influence of the wind on the pressure of the air, I placed each observation of the barometer in the column having the observed wind at the top, and took the averages of the numbers in each column. The result for the three winter months (subtracting 29 inches) are shown in column tenth and the averaged numbers in column eleventh. Similar results for the three summer months are shown in columns twelve and thirteen.

On comparing the numbers in this table we see that in winter at Philadelphia the lowest temperature occurs with a wind from the N.W., and in summer with a wind from a point about 15° west of north.

Now if we suppose a mass of air to be transferred from a higher latitude to a lower, we should expect that its relative temperature would be the lowest when it moved in a direction perpendicular to the isothermal lines. Observing this rule we should conclude that in winter the coldest wind at Philadelphia must come from a quarter about 15° west of north, provided it commenced its motion from any place within 600 miles from Philadelphia. But if it came from a distance of over 1000 miles from Philadelphia then the coldest wind would come from a point 30° west of north. But the coldest wind actually comes from a point 45° west of north; that is, at Philadelphia in winter the coldest wind blows from a point 15° more westerly than the coldest region about Philadelphia.

In summer, if we extend the comparison to a distance of 1000 miles from Philadelphia, we shall find the coldest region to lie in a N.E. direction; but if we confine ourselves to a radius not exceeding 600 miles, we shall find nearly the same temperature prevailing in all directions between the limits of N.E. and N. 25° W. But the coldest wind is observed to blow from a point N. 15° .W., which lies within the limits above determined. On the whole, we conclude that at Philadelphia the coldest wind comes very nearly from the coldest region within a distance of from 500 to 1000 miles from Philadelphia, with a suspicion, however, that the former is a few degrees more westerly than the latter.

In winter the warmest wind at Philadelphia is found to blow from a direction S. 40° E., while in summer it blows from the S.W. The former direction takes us to the Gulf Stream at about its nearest point, and at a distance of 250 miles. In summer the warmest region within 400 or 500 miles of Philadelphia lies in a direction S. 30° W., while the warmest wind blows from a point 15° more westerly. On the whole, the observations indicate that both the warmest and coldest winds at Philadelphia blow pretty nearly from the regions of greatest heat and cold, but there is reason to suspect that these directions are not quite coincident.

From the table of monthly minima of temperature at New Haven given in my former article, (this Jour., vol. ix, p. 7) it will be seen that the average monthly minimum is 25° below the mean temperature of the corresponding month. The table last given shows that a small portion of this effect (viz. 5°) may be ascribed to the influence of the direction of the wind, but there remains unexplained *four-fifths* of the whole effect which is to be ascribed to the influence of other causes.

The preceding table shows that both in summer and winter the force of vapor at Philadelphia is greatest with the same wind which brings the highest temperature; and it is lowest with the wind which brings the lowest temperature. The deviations from this rule are so small as to render it probable that the discrepancies would entirely disappear in the means of a long series of observations.

Since cold air has a greater density than warm air, and dry air has a greater density than vapor of water, it might be expected that the wind which brings the lowest temperature and the least vapor, would bring the highest pressure. We see, however, from the preceding table that such is not the case. In winter the highest pressure comes with a wind from the N.E., or perhaps N. 55° E.; while in summer the highest pressure comes with an east wind, which directions are distant more than 90° from the coldest quarter of the horizon. So, also, in winter, the lowest pressure comes with a S.W. wind, and in summer with a west wind, both of which directions are quite distant from the warmest quarter of the horizon. It seems probable that the excess of pressure which accompanies an easterly or N.E, wind is but the result of the high barometer which usually precedes a N.E. storm.

Diurnal inequality in the rain-fall.

In my former article (this Jour., vol. x, p. 3) I noticed a diurnal inequality in the progress of storms and was hence led to infer that there must be a diurnal inequality in the fall of

rain. In searching for observations to test this conclusion, I found a decided diurnal inequality in the rain-fall at Philadelphia showing a maximum about 6 P. M. and a minimum at 3 A. M. The observations made by the United States Signal Service did not show any decided diurnal inequality, owing, perhaps, to their including only three daily observations. In a series of hourly observations made at seven stations in Great Britain I found evidence of two daily maxima and two daily minima.

Since the publication of my former article I have found in Kreil's Klimatologie von Böhmen the results of ten years' observations at Prag, lat. 50° 5′, which show a decided diurnal inequality, having a maximum about 4 P. M. and a minimum about 7 A. M., with a second maximum which is less distinctly marked. The following table shows the average annual rain-fall at Prag as deduced from observations from 1850 to 1859 expressed in Paris lines:

Rainfall at Prag, Austria.

Hour.	Rain-fall.	Hour.	Rain-fall.
Midnight.	6·864	Noon.	7·063
1 A. M.	6·507	1 P. M.	8·901
2	5·986	2	8·837
3	6·514	3	10·207
4	6·313	4	10·778
5	6·771	5	10·845
6	5·637	6	8·835
7	5·049	7	8·211
8	6·949	8	6·927
9	5·722	9	6·374
10	5·798	10	6·953
11	6·072	11	6·542

These numbers follow a law bearing a close resemblance to that of the Philadelphia observations, and lead us to presume that a similar law must prevail in the fall of rain over a considerable portion of the United States.

I have received the hourly observations of rain-fall at seven stations of Great Britain complete for the year 1874. At most of the stations there are evidently two periods of maximum rain-fall, but the time of maximum appears to depend very much upon local circumstances.

Comparison of storm paths in America and Europe.

In comparing the tracks followed by storms in America and Europe I have depended chiefly upon the following materials:

1. The daily United States Signal Service maps from 1871 to 1875, and especially the monthly maps showing the tracks of storm centers.

2. Atlas des mouvements generaux de l'atmosphere, redigé par l'observatoire Imperial de Paris, embracing 18 months, from June, 1864, to Dec. 1865.

3. Cartes synoptiques journalieres construites par N. Hoffmeyer, Copenhagen, embracing 9 months, from Dec. 1873 to Aug. 1874.

In order to determine what may be called the average track of storm centers in the United States, I ruled a large sheet of paper with several vertical columns headed 122°, 117°, 107°, etc., these numbers denoting degrees of longitude from Greenwich. I then took one of the monthly maps showing the tracks of storm centers, and following each of the tracks in succession determined in what latitude it crossed the meridians indicated at the top of the table, and the results were set down in the appropriate column. I proceeded in the same manner with each of the monthly maps and then took the average of all the numbers in each column. The results are shown in the first two columns of the following table; where column first shows the meridians of longitude from Greenwich, and column second shows the average latitude in which each of these meridians is intersected by the storm paths. The curve thus determined is traced on the accompanying chart and passes over the center of Lake Erie. It will be seen that the average direction of storm paths is not the same on all meridians. The directions given in my former article (see this Jour., vol. x, p. 1) must be understood to be the average direction of storm paths for the region covered by the United States observations; and this represents pretty nearly the mean direction for a place whose latitude is 42½° and longitude 83½° W., which is nearly the position of Detroit, Michigan.

Average direction of storm-paths.

U. S. Weather Maps.		Paris Maps.		Danish Maps.		Mean of Par. and Dan.	
Long. from Greenwi'h.	Latitude	Longitude from Paris.	Latitude.	Longitude from Paris.	Latitude.	Longitude from Paris.	Latitude.
122° W.	45·8°	60°—45° W.	46·2°	60°—50° W.	53·7°	55° W.	50·0°
117	46·9	45 —30	46·5	50 —40	59·5	45	52·9
107	44·7	30 —15	47·5	40 —30	61·8	35	54·2
97	42·2	15 — 0	53·0	30 —20	62·6	25	54·9
87	42·5	0 —15 E.	54·5	20 —10	61·5	15	55·6
77	42·6	15 —30	56·9	10 — 0	63·1	5 W.	58·3
67	45·2	30 —45	51·4	0 —10 E.	58·9	5 E.	56·7
62	45·9			10 —20	57·8	15	56·9
				20 —30	61·6	25	59·0
				30 —40	61·2	35	56·8
				40 —50	58·5	45	55·0
				50 —60 E.	55·3	55 E.	53·3

I proceeded in a somewhat similar manner with the Paris maps, but since these maps do not generally exhibit lines

drawn so as to show the tracks of storms from day to day, I placed in one column the latitudes of all the storm centers between the meridians of 60° and 45° W. from Paris; in a second column I placed those between the meridians of 45° and 30° W., and so on for each 15° of longitude. I then took the average of all the latitudes in each of the columns. The result is shown in columns third and fourth of the preceding table, and the path thus determined is traced on the accompanying chart. This path passes over Dublin, and will be seen to form a natural continuation of the track deduced from the American observations. This result is doubtless accidental and is due to the fact that near the American coast the observations from which the Paris maps were constructed were derived from a region extending but little north of the stations of the United States Signal Service. If the Paris maps had included observations from Labrador and Greenland the average track of the storms represented would have been more northerly than it now is.

I proceeded in a similar manner with Hoffmeyer's charts except that the meridians were selected at intervals of 10°, and the results are shown in columns fifth and sixth. The path thus determined lies several degrees north of that previously determined, and this arises from the fact that the maps exhibit the results of observations made in Greenland and Iceland as well as from more southern latitudes. In order to deduce an average result from the French and Danish maps I have combined them in a single series, and the result is shown in columns seventh and eighth of the preceding table. The path thus determined is traced on the accompanying chart and passes through the northern extremity of Scotland.

In order to show the connection between storm paths and the mean height of the barometer, I have drawn upon the same chart two other barometric lines. The mean height of the barometer at the level of the sea varies with the latitude of the place. On the Atlantic ocean at the equator the mean height of the barometer is about thirty inches. If from this point we travel northward the pressure increases, and in latitude 30° becomes about 30·2 inches. Thence the pressure diminishes to 29·6 inches near latitude 70°, from which point the pressure slightly increases as we advance northward. A somewhat similar result takes place in going from the equator to the North Pole upon any meridian, but the maximum pressure is not the same under all meridians, and the same is true of the minimum pressure. The undulating line near the bottom of the accompanying chart shows the line of the greatest mean pressure varying on different meridians from about 30 inches to 30·2 inches. The undulating line near the top of the chart

shows the line of the least mean pressure, being about 29·6 inches on the meridian of Greenwich and increasing somewhat as we proceed either east or west from that meridian. These lines are drawn chiefly from data collected by Alexander Buchan. (See Edinburgh Phil. Trans, vol. xxv.)

We perceive then that at all places near the southern margin of the chart the mean pressure of the atmosphere is greater than it is further northward, and this is generally sufficient to cause an average surface wind from south to north although the wind advances from a warmer to a colder region. On the other hand, at places near the northern margin of the chart the mean pressure of the atmosphere is somewhat greater than it is further south, and this force combined with a lower mean temperature causes a surface wind from north to south. Here then are permanent causes producing winds from opposite directions near the upper and lower portions of the chart, and these must be a permanent source of storms independent of those inequalities of pressure which arise from causes of a more local nature.

The average path of storms in their progress from America to Europe is apparently modified by the line of greatest mean pressure. This line has a more northerly position in Europe than it has in America, and this may be the reason why storm tracks generally bend northward in advancing from America to Europe. There are some minor particulars in which storm paths are apparently modified by the line of greatest mean pressure; but instead of attaching importance to coincidences which may prove to be accidental, it is more prudent to wait and see if these peculiarities are confirmed by further observations.

Oscillations of the barometer in different latitudes.

For the purpose of determining in what region of the globe the oscillations of the barometer are the greatest, I have prepared a table showing the mean monthly oscillation of the barometer at as many stations as possible in high northern latitudes. A few of the numbers in the following table are derived from Kaemtz Meteorology, edited by C. V. Walker, p. 297. The other numbers have been collected by myself from various sources which are indicated in the last column, and some of the results have required a careful discussion of many years' observations. Column fourth shows the average monthly range of the barometer for the three winter months, and column fifth shows the same for the three summer months expressed in English inches

As some of these numbers depend upon observations of only one year, and therefore do not represent mean values very ac-

curately, I have endeavored to combine them so as to obtain a few normal values. I combined all the observations north of latitude 70° in one general average, and all the observations between latitudes 60° and 70° in a second average. I then divided the observations of Kaemtz (Met., p. 298) into similar groups, each embracing ten degrees of latitude, viz., 60°—50°; 50°—40°, etc., and thus obtained the normal values shown in the table at the bottom of this page.

Mean monthly oscillation of the barometer for winter and summer.

Place.	Latitude.	Longitude.	Range of bar. Win'r	Range of bar. Sum'r	Authority.
Van Rensselaer Harbor,	78° 37′	70° 53′ W.	1·483	0·727	Kane's obs. reduced by Schott.
Northumberland Sound,	76 52	97 0 W.	1·116	0·728	Belcher Expedition, 1852–4.
Wellington Channel,	75 31	92 10 W.	1·130	0·587	" "
Melville Island,	74 47	110 48 W.	1·220	0·693	Parry's first voyage.
Upernivik, Greenland.	72 48	55 53 W.	1·451	0·697	Collectanea Met., 5 years obs.
Vardoe, Norway,	70 22	31 7 E.	1·776	0·937	Met. Iag. i Norge, 2 years obs.
Boothia Felix,	70 3	91 52 W.	1·231	0·899	Ross 2d Arctic Expedition, 2½ years.
Alten, Finmark,	69 58	23 2 E.	1·424	0·907	Br. Ass. Rep., 1848–50, 3 years.
Kaafiord, Finmark,	69 56	23 5 E.	1·496	0·901	Gaimard Met., v. 2, p. 451, 3 years.
Tromsoe, Norway,	69 39	18 58 E.	1·721	0·791	Met. Iag. i Norge, 1 year obs.
Jacobshaven, Greenland,	69 12	51 0 W.	1·496	0·906	Collectanea Met., 10 years obs.
Bodoe, Norway,	67 17	14 24 E.	1·913	0·921	Met. Iag. i Norge, 2 years obs.
Ft. Confidence, Br. N. A.,	66 54	118 49 W.	1·315	-- --	Athabasca obs., p. 355, 7 months.
Torneo, Finland,	65 51	24 14 E.	1·512	0·851	Kaemtz Met., p. 298.
Haparanda, Sweden,	65 51	24 11 E.	1·675	0·892	Met. Iakttagelser, 1859–69.
Godthaab, Greenland,	64 10	51 53 W.	1·409	0·685	Collectanea Met., 3 years obs.
Naes, Iceland,	64 9	22 0 W.	1·639	0·971	Observationes Met., 15 years obs.
Umea, Sweden,	63 50	20 18 E.	1·555	0·868	Kaemtz Met., p. 298.
Christiansund, Norway,	63 7	7 45 E.	1·642	0·929	Met. Iagttagelser i Norge, 9 years obs.
Hernosand, Sweden,	62 38	17 57 E.	1·644	0·896	Met. Iakttagelser, 1859–69.
Aalesund, Norway,	62 29	6 9 E.	1·658	0·949	Met. Iag. i Norge, 9 years obs.
Dovre, Norway,	62 5	9 7 E.	1·559	0·870	Met. Iag. i Norge, 5 years obs.
Jakoutsk, Siberia,	62 2	129 42 E.	1·012	0·803	Kaemtz Met., p. 298.
Fahlun, Sweden,	60 36	15 37 E.	1·640	0·835	Met. Iakttagelser, 1859–69.
Abo, Russia,	60 27	22 19 E.	1·465	0·778	Kaemtz Met., p. 298.
Bergen, Norway,	60 24	5 18 E.	1·654	0·904	Kaemtz Met., p. 298 & Met. Iag. i Norge.

Monthly oscillation of the barometer (normal values).

Latitude.	Winter inch.	Summer inch.	Winter comp.	Winter O—C.	Summer comp.	Summer O—C.
6° 12′	0·110	0·106	0·125	—0·015	0·115	—0·009
15 40	0·198	0·164	0·234	— ·036	·169	— ·005
24 10	0·424	0·236	0·404	+ ·020	·255	— ·019
34 57	0·664	0·362	0·690	— ·026	·398	— ·036
46 2	1·068	0·556	1·029	+ ·039	·568	— ·012
54 13	1·315	0·744	1·280	+ ·035	·694	+ ·050
64 46	1·549	0·869	1·566	— ·017	·837	+ ·032
74 9	1·344	0·753	1·757	— ·413	·933	— ·180

The winter oscillations up to lat. 65° are pretty well represented by the formula:

$$W = 1{\cdot}890 \sin^2 l + 0{\cdot}104 \cos^2 l,$$

and the summer oscillations by the formula:

$$S = 1{\cdot}000 \sin^2 l + 0.104 \cos^2 l.$$

The differences between the observed and computed values are shown in columns fifth and seventh in the above table. These results indicate a steady increase in the mean monthly oscillation up to about lat. 65°, and from that point the oscillation diminishes as we proceed northward. The term $0{\cdot}104 \cos^2 l$ represents approximately the diurnal oscillation of the barometer, and the

Storms on the Atlantic Ocean by Maury's Charts.

Lat.	80°–75°	75°–70°	70°–65°	65°–60°	60°–55°	55°–50°	50°–45°	45°–40°	40°–35°	35°–30°	30°–25°	25°–20°	20°–15°	15°–10°	10°–5° W.	5°–0°
60°–55											60 16 27	102 38 37	123 35 28	117 31 27	78 12 15	30 3 10
55–50								150 57 38	420 111 26	510 140 27	694 169 24	850 159 19	932 117 12	1260 152 12	1393 133 10	583 46 8
50–45					126 11 9	288 28 10	919 121 13	1242 209 17	1570 369 24	1740 277 16	1627 242 15	1539 165 11	1478 160 11	1312 156 12	920 85 9	313 13 4
45–40		1820 126 7	3249 260 8	2544 266 11	2679 269 10	2419 241 10	1863 280 15	1581 234 15	1119 127 11	732 66 9	396 58 15	269 44 16	168 16 9	128 9 8	67 1 1	0
40–35	243 8 4	4193 607 14	2974 475 16	1797 393 22	1393 177 13	1100 115 10	773 62 8	480 28 6	349 27 8	242 23 9	341 35 10	268 5 2	302 24 8	340 7 2	334 9 3	225 14 6
35–30	1534 126 8	2265 231 10	1645 137 8	766 65 9	723 72 10	860 71 8	986 60 6	893 48 5	747 27 3	392 25 6	175 4 2	129 0 0	223 9 4	77 0 0	3 0 0	
30–25	1945 81 4	1393 30 2	1137 57 5	948 17 2	394 17 4	351 6 2	564 5 1	726 9 1	958 61 6	663 6 1	209 8 4	153 0 0	87 6 7			
25–20	316 12 4	380 9 2	262 4 2	650 7 1	637 6 1	267 6 2	262 9 3	452 18 4	806 4 0	664 25 4	338 0 0	136 0 0	15 0 0			
20–15	243 4 2	320 2 1	152 0 0	183 0 0	459 1 0	541 4 1	326 1 0	302 10 3	449 6 1	711 13 2	638 8 1	159 0 0	6 0 0			
15–10	65 0 0	0 0 0	58 1 2	53 0 0	96 1 1	387 0 0	594 1 0	508 0 0	415 3 1	667 9 1	835 21 3	622 0 0	225 0 0			
10–5					23 0 0	0 0 0	289 0 0	668 0 0	632 0 0	739 3 0	1667 5 0	1109 0 0	483 0 0	716 0 0	80 0 0	70 0 0
5–0						0 0 0	95 0 0	421 0 0	613 0 0	1004 0 0	2004 3 0	1262 0 0	335 0 0	107 0 0	362 1 0	233 0 0

other term of the formulas varies as the square of the sine of the latitude, and this law of increase holds pretty closely up to about latitude 65°. That part of the barometric oscillation represented by the first term of the formula is the effect of storms, and the oscillation diminishes within the Arctic circle.

These results seem to indicate that in the Northern Hemisphere, storms increase in frequency as we proceed northward as far as latitude 60° and perhaps somewhat farther. The same result is shown by Maury's storm chart of the North Atlantic. The preceding table presents a summary of the results of this chart. The ocean is divided into squares by parallels of latitude drawn at intervals of five degrees from each other, and meridians of longitude at intervals of five degrees. Each square of the preceding table contains three numbers. The first shows the number of observations within the given square, each observation representing a period of eight hours. The second shows the number of gales reported, and the third is the average number of gales occurring in a hundred observations. Thus in the square included between the parallels of 40° and 45° of north latitude, and between the meridians of 45° and 50° west longitude from Greenwich, the first number is 1863, which shows the number of observations obtained in that square. The second number is 280, which denotes the number of gales reported; the third number is 15, which denotes that the number of gales was 15 per cent of the whole number of observations. An inspection of this table will show that on each meridian the frequency of gales increases with the latitude up to the highest latitude from which observations are reported.

Storms traced across the Atlantic Ocean.

When storms from the American continent enter upon the Atlantic Ocean they generally undergo important changes in a few days and are frequently merged in other storms which appear to originate over the ocean, so that we can seldom identify a storm in its course entirely across the Atlantic. The following are the only cases I have found on the French and Danish charts (embracing a period of 27 months) in which storms can be pretty distinctly traced across the Atlantic.

1. Nov. 30—Dec. 11, 1864. A storm traced from Newfoundland to Ireland.
2. April 20—May 3, 1865, traced from Labrador to Ireland.
3. May 26—29, 1865, from Gulf St. Lawrence to Ireland.
4. Oct. 2—10, 1865, from Cape Cod to Ireland.
5. Oct. 11–17, 1865, from Newfoundland to Ireland.
6. March 1—5, 1874, from Hudson Bay to North Cape.
7. April 14—17, 1874, from Hudson Bay to Norway.

8. April 16—23, 1874, from Gulf St. Lawrence to Norway.
9. May 23—30, 1874, from Gulf St. Lawrence to Norway.
10. Aug. 1—4, 1874, from Gulf of St. Lawrence to North Cape.
11. Aug. 12—17, 1874, from Hudson Bay to Norway.

If the observations each day were sufficiently numerous to show the isobaric curves for every part of the Atlantic Ocean, doubtless many more storms might be traced from America to Europe, but it is presumed that such cases do not occur on an average more than once or twice a month. The storms of Europe generally have their origin considerably east of the American Continent and soon become so violent as to draw within their influence any small barometric depression which started from America.

Velocity of Ocean Storms.

The average velocity of storms upon the Atlantic Ocean as deduced from 134 cases on the French maps is 19·3 miles per hour; the velocity deduced from 49 cases on the Danish maps is 20·3 miles per hour; giving an average of 19·6 miles per hour from both series of maps. The average velocity for the storms of the United States as deduced from 485 cases is 26 miles per hour. From a considerable number of cases in Europe, Prof. Mohn has deduced an average velocity of 26 7 miles per hour. These numbers indicate that storms travel with less velocity over the Atlantic Ocean than they do over the Continents of America and Europe; and it seems to follow that the progressive movement of a storm is not the result of a *simple drifting* of the atmosphere; for it seems probable that the average progress of the atmosphere in an easterly direction is as rapid over the Atlantic Ocean as it is over North America.

Storms of Jan. 29—*Feb.* 8, 1870, *on the Atlantic Ocean.*

A succession of storms of unusual severity passed over the Atlantic, between Jan. 29 and Feb. 8, 1870, an account of which has been published by Capt. Henry Toynbee, of the London Meteorological office. On the 30th of January an area of low barometer prevailed near Nova Scotia; on the 31st it was east of Newfoundland; and on the 1st of February it was merged in another storm which had prevailed for several days on its eastern side. On the 2d of February a second storm center appeared near Newfoundland; on the 3rd it had advanced east about 700 miles; and on the 4th it became merged in another storm off the Irish coast.

On the morning of the 5th a third storm appeared near the center of the Atlantic, which must have developed with unusual rapidity, since on the preceding day, observations had indicated no great atmospheric disturbance in that neighborhood.

The isobar of 29 inches is shown on the accompanying chart. On the afternoon of the same day, this storm blended with another storm on its eastern side, and there resulted one of the most violent hurricanes ever experienced on the Atlantic Ocean. At 6 P. M. the barometer fell to 27·33 inches, which Capt. Toynbee pronounces the lowest ever observed on this part of the Atlantic. The accompanying chart represents the isobar of 29 inches on the morning of the 6th, when the diameter of this curve was over 1000 miles, and the diameter of the isobar of 30 inches was over 2000 miles. During the next two days the storm advanced slowly towards the southeast, and its severity was much diminished. The accompanying chart shows the isobar 29·5 inches on the morning of Feb. 8th. During this interval of three days the center of the storm had moved only about 900 miles, showing an average velocity of about 12 miles per hour.

Application of Ferrel's formula.

In vol. viii of this Journal, p. 343, Prof. Ferrel has given a formula which enables us to compute the depression of the barometer resulting from a violent storm. If we divide the denominator of this formula by the number of inches in a mile, and suppose the wind to move in a circle, the formula becomes

$$G = \frac{v \sin l}{250} + \frac{v^2}{131r},$$

where G is expressed in inches, but v and r are expressed in miles. I have applied this formula to the storm of Feb. 5th, 1870, and the results are shown in the following table. Column first shows the isobars which have been selected as the basis of comparison; column second shows the radius of each isobar as nearly as can be determined from the observations of Capt. Toynbee's memoir; and column third shows the velocity of the wind in miles on each of these isobars. These velocities were obtained by taking the mean of the various observations corresponding to the barometric heights given in column first. These velocities were recorded in the numbers of Beaufort's scale (0–12) and were reduced to miles by the table in Scott's Met. Instruments, p. 58. Column fourth shows the gradient to 100 miles computed by the above formula, for points midway between the several isobars selected. If this gradient be supposed to be maintained for a distance equal to the distance between the isobars, it will show a change of barometric pressure about the same as that actually observed. For the inner circle, the computed gradient will represent the observed depression of the barometer if we suppose that near the center of the storm there was a considerable mass of air revolving with a diminished velocity.

Ex. 1.—*Storm of Feb.* 5, 1870, *Atlantic Ocean, lat.* 51° 3′ *N.*

Barometer. Inches.	Radius of Isobar. Miles.	Velocity, miles.	Gradient to 100 miles.
27·33	0	90	1·79
28·00	60	66	·42
28·50	200	59	·25
29·00	400	52	·18
29·50	680	45	·15
30.00	1020	38	

I have made a similar application of the formula to two violent cyclones of recent occurrence on the coast of the United States, and the results are shown below. In the Punta Rassa cyclone the assumed velocities 90 and 70 miles agree pretty well with the velocities actually observed; the velocities 50 and 35 miles are somewhat greater than the observations at the surface of the earth, but may be presumed to have been the velocities at a little elevation above the earth's surface. The velocities assumed for the Indianola cyclone are the velocities actually observed or estimated at Indianola.

Ex. 2.—*Storm of Oct.* 6, 1873, *Punta Rassa, lat.* 27° 0′.

Barometer.	Radius of Isobar.	Velocity.	Gradient to 100 miles.
28·40	0	90	2·10
29·00	50	70	·33
29·50	200	50	·11
30·00	650	35	

Ex. 3.—*Storm of Sept.* 16, 1875, *Indianola, lat.* 28° 31′.

Barometer.	Radius of Isobar.	Velocity.	Gradient to 100 miles.
28·90	0	90	1·00
29·50	100	60	·15
30.00	500	35	

The following is an example of a great inland storm of unusual severity. Column third shows the *greatest* velocity of the wind observed at any station near the corresponding isobars in column first, and column fourth shows the velocity assumed in computing the gradients in column fifth.

Ex. 4.—*Storm of Nov.* 18, 1873, *New England, lat.* 41°

Barometer inches.	Radius of Isobar. Miles.	Velocity of wind.		Gradient to 100 miles.
		Observed.	Assumed.	
28·60	100	50	56	·24
29·00	300	57	48	·15
29·50	700	27	40	·10
30·00	1200	28	30	

Stationary Storms.

When a storm center has crossed the United States and passed to Nova Scotia or Newfoundland, we often find on the United States Weather Maps for two or three subsequent days the word *low* on the northeast corner of the maps, seeming to indicate that the center of the storm remained during that period nearly stationary. The Danish maps (from Dec., 1873, to Aug., 1874,) show us that storms do sometimes remain nearly stationary for several days.

Case I. From the 5th to the 8th of March, 1874, a violent storm moved from New Mexico to the St. Lawrence valley. On the 9th the center of this storm was a little north of Halifax; on the 10th it was still near the same place; on the 11th it had moved northeast nearly 400 miles; on the 12th it had moved south about 200 miles; on the 13th it had moved north about 200 miles; on the 14th it had moved south about 200 miles; and on the 15th it moved northeast about 700 miles. Thus during five days (March 9–14) the center of the storm had advanced less than 350 miles, being an average motion of less than three miles an hour, and during the first four days the barometric depression was greater than it was on the 8th.

Case II. From April 26th to 30th, 1874, a storm moved across the United States from Colorado to the St. Lawrence valley. During the next day (May 1st) the storm was stationary; on the 2d it moved a little to the southeast; on the 3d it moved a little to the east; and on the 4th it reached St. Johns, Newfoundland. Thus in four days the center moved 775 miles, being an average rate of about eight miles an hour; and during the first half of this time the average movement scarcely exceeded four miles an hour.

In preparing the materials for this article, I have been assisted by Mr. Edward S. Cowles, a graduate of Yale College of the class of 1873.

ART. II.—*Studies on Magnetic Distribution*; by HENRY A. ROWLAND, of the Johns Hopkins University, Baltimore.

(Continued from page 458 of the last volume.)

V.

LET us now consider the case of that portion of the bar which is covered by the helix. First of all, when the helix is symmetrically placed on the rod, equations (5) and (6) will apply. As Q''_e is the quantity which is usually taken to represent

the distribution of magnetism, being nearly proportional to the "surface-density" of magnetism, I shall principally discuss it.

In the first place, then, this equation shows that the distribution of magnetism in a very elongated electro-magnet, and indeed of a steel magnet, does not change when pieces of soft iron bars of the same diameter as the magnet are placed against the poles, *provided that equal pieces are applied to both ends;* otherwise there is a change. This result would be modified by taking into account the variation of the permeability, &c.

Let us first consider the case where the rod projects out of the end of the helix, as in Tables V, VI and VII. By giving proper values to the constants we obtain the results given in the last columns of the table. The agreement with observation is in most cases very perfect. We also see the same variation of r that we before noticed in the rest of the curves, and we see that it is in just the direction theory would indicate from the change of μ.

In these tables we come to a very important subject, and one to which I called attention some years back, namely, the *change in the distribution when the magnetizing-force varies, and which is due to change of permeability.* The following tables and figures show this extremely well, and are from very long rods with a helix a foot long at their center, as in the last three tables. The bar in both these tables was ·19 inch in diameter and 5 feet long. The zero-point was at the center of the bar and of the helix. The tables give values of Q'_e for the magnetizing-forces which appear at the head of each column, and which are the tangents of the angles of deflection of the needles of a tangent-galvanometer. Table VIII. only gives the part covered by the helix. Both tables are from the mean of both ends of the bar.

TABLE VIII.

x.	Strength of magnetizing current.			
	·108.	·194.	·378.	·600.
0				
1	2·7	3·2	·7	·6
2			·9	·6
3	2·4	2·7	·9	·8
4	3·3	3·9	1·7	·8
5	4·0	6·0	4·0	3·2
6	5·7	8·7	9·3	14·7

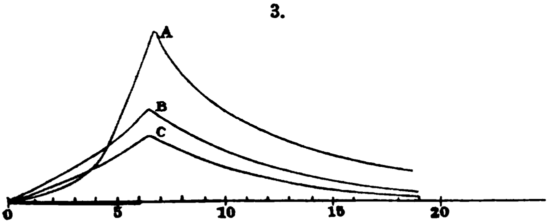
These experiments show in the most positive manner the effect we are considering, and we are impressed by them with the great complication introduced into magnetic distribution by the variable character of magnetic permeability.

TABLE IX.

x.	C. ·257.	B. ·363.	A. 1·303.
0, 1, 2	2·5	3·1	1·1
			1·3
2, 3, 4	7·2	4·1	2·1
		5·9	4·0
4, 5	6·1	8·2	9·6
5, 6	7·7	10·9	18·6
6, 7	7·9	11·5	21·3
7, 8	6·5	9·0	16·8
8, 10	10·0	15·0	27·4
10, 12	6·2	10·9	20·9
12, 15	5·0	9·8	21·5
15, 18	2·0	4·7	14·8
18, 30	2·0	3·6	16·5

In fig. 3 I have represented the distribution on half the bar as given in Table IX, the other half being of course similar. Here the greatest change is observed in the part covered by the helix, though there is also a great change in the other part.

3.



Plot of Table IX, showing surface-density for different values of the magnetizing-force.

These tables show that, as the magnetization of the bar increases, *at least beyond a certain point*, the curves on the part covered by the helix increase in steepness; and the figure even shows that near the middle of the helix an *increase of magnetizing-force may cause the surface-density to decrease;* and Table VIII. shows this even better. Should we calculate Q″, however, we should always find it to increase with the magnetizing-force in all cases. These effects can be shown also in the case where the bar does not extend beyond the helix, but not nearly so well as in this case, seeing that here Q″ can obtain a greater value.

Assuming that μ is variable, the formula indicates the same change that we observe; for as Q″ increases from zero upward, μ will first increase and then decrease; so that as we increase the magnetizing-force from zero upward, the curve should first decrease in steepness and then increase indefinitely in steepness.

In these tables the decrease of steepness is not very apparent, because the magnetization is always too great, and indeed on this account it is difficult to show it; but in Tables V, VI and VII. this action is shown to some extent by the values of r in the formulæ. The change of distribution with the helix arranged in this way at the center of the bar is greater than in almost every other case, because the magnetism of the bar Q″ can change greatly throughout the whole length of the helix, and thus the value of r be changed, and so the distribution become different.

The next case of distribution which I shall consider is that of a very long rod having a helix wound closely around it for some distance at one end.

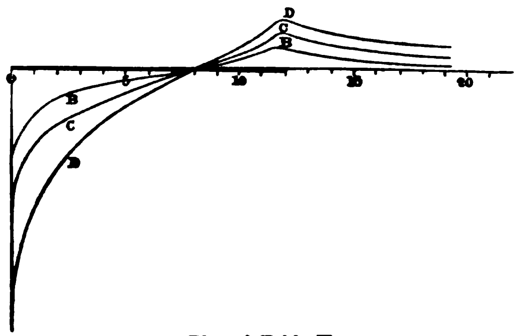
Table X. is from a bar 9 feet long with a helix wound for one foot along one end. The bar was ·25 inch in diameter. All except the first column is the sum of two results with the current in opposite directions, and after letting the bar stand for some time, as indeed was done in nearly every case. The first column contains twice the quantities observed, so as to compare with the others. The zero-point was at the end of the bar covered by the helix.

TABLE X.

x and L.	A. ·245.	B. ·360.	C. ·600.	D. 1·09.
0				
1	+17·6	+29·4	+52·0	+108·7
2	+ 9·6	+16·8	+31·5	+ 60·1
3	+ 7·4	+13·1	+24·3	+ 45·8
4	+ 5·4	+ 9·8	+19·1	+ 34·1
5	+ 3·4	+ 7·2	+14·7	+ 22·8
6	+ 2·0	+ 4·6	+ 9·9	+ 16·0
7	+ 0·6	+ 2·4	+ 5·4	+ 9·6
8	− ·8	+ ·3	+ 1·2	+ ·6
9	− 1·8	− 1·6	− 2·1	− ·3
10	− 3·0	− 3·6	− 6·6	− 8·8
11	− 5·0	− 6·3	− 8·6	− 15·6
12	− 7·4	−10·0	−16·4	− 27·1
13	− 8·4	−10·0	−16·9	− 26·5
14	− 6·0	− 7·9	−14·5	− 22·6
15	− 5·2	− 7·0	−12·5	− 21·0
16	-----	− 5·3	−11·9	− 19·0
18	-----	− 9·4	−19·1	− 31·2
20	-----	− 5·3	−15·2	
24	-----	− 6·5	−19·3	
36	-----	− 5·6	− 6·0	
48	-----	− ·7	− 1·2	

The value of Q''_{ϵ} between 0 and 1 includes the lines of force passing out at the end of the bar, and is therefore too large.

4.



Plot of Table X.

In fig. 4 we have a plot of the results found for this bar. The curves are such as we should expect from our theory except for the variations introduced by the causes which we have hitherto considered. Thus the sharp rise in the curve when near the end of the bar has already been explained in connection with Table III. A small portion of it, however, is due to those lines of induction which pass out through the end section of the bar, and in future experiments these should be estimated and allowed for. When considering surface-density we should also allow for the direct action of the helix, though this is always found too small except in very accurate experiments.

To estimate the shape of the curve theoretically in this case, let us take equation (4) once more, and in it make $s' = \infty$ and $s'' = \sqrt{RR'}$ which will make it apply to this. We shall then have $A' = -1$, and $A'' = \infty$.

Whence for the positive part of Q''_ε we have

$$Q'_\varepsilon = -\frac{\mathfrak{H}\Delta L}{2R'r}\{-1+2\varepsilon^{r(x-b)}-\varepsilon^{2r(x-b)}\} = \frac{\mathfrak{H}\Delta L}{2R'r}\{1-\varepsilon^{r(x-b)}\}^2;$$

and for the negative part

$$Q'_\varepsilon = -\frac{\mathfrak{H}\Delta L}{2R'r}(1+\varepsilon^{2r(x-b)})(1-\varepsilon^{-rx});$$

therefore the real value is

$$Q'_\varepsilon = -\frac{\mathfrak{H}\Delta L}{2R'r}(\varepsilon^{r(x-b)}(\varepsilon^{-rb}-2)+\varepsilon^{-rx}).$$

And if x is reckoned from the end of the rod, we have

$$Q'_\varepsilon = \frac{\mathfrak{H}\Delta L}{2R'r}\varepsilon^{-r(b+x)}\{1-2\varepsilon^{rb}+\varepsilon^{2rx}\}. \quad . \quad . \quad . \quad . \quad . \qquad (10)$$

When $x=0$, this becomes

$$\frac{\mathfrak{H}\Delta L}{2R'r}\varepsilon^{-rb}(2-2\varepsilon^{rb});$$

and when $x=b$, it becomes

$$\frac{\mathfrak{H}\Delta L}{2R'r}\varepsilon^{-2rb}(1-2\varepsilon^{rb}+\varepsilon^{2rb}),$$

the ratio of which is

$$\tfrac{1}{2}(\varepsilon^{-rb}-1);$$

and this is the ratio of the values of Q''_ε at the ends of the helix. When b is 12 inches, as in this case, we get the following values of this ratio:—

$r=$	·05.	·1.	·15.	·20.	·30.	∞.
$-\frac{1}{2}(\varepsilon^{-rb}-1)=$	·2256	·3494	·4173	·4546	·4863	·500
$\frac{-2}{\varepsilon^{-rb}-1}=$	4·43	2·86	2·40	2·20	2·06	2·00

To compare this with our experiments, let us plot Table X. once more, rejecting, however, the end observations and completing the curve by the eye, thus getting rid of the error introduced at this point. We then find for this ratio, according to the different curves,

B.	C.	D.
2·1	2·3	3·2

It is seen that these are all above the limit 2, as they should be, though it is possible that it may fall below in some cases owing to the variation of the permeability. As the magnetization increases, the values of the above ratio show that r decreases, as we should expect it to do from the variation of μ.

To find the neutral point in this case, we must have in formula (10)

$$\varepsilon^{2rx}=2\varepsilon^{rb}-1,$$

where x is the distance of the neutral point from the end. Making $b=12$, we have from this

$r=$	·05.	·10.	·15.	·20.	·30.	∞.
$x=$	10·1	8·96	8·31	7·89	7·39	6·00

By experiment we find that the neutral point is, in all the cases we have given in Table X, between 7·5 and 8·1 inches, which are quite near the points indicated by theory for the proper values of r, though we might expect curve D to pass through the point $x=9$, except for the disturbing causes we have all along considered.

Our formulæ, then, express the general facts of the distribution in this case with considerable accuracy.

These experiments and calculations show the change in distribution in an electro-magnet when we place a piece of iron

against *one pole only.* In an ordinary straight electro-magnet the neutral point is at the center. When a paramagnetic substance is placed against or near one end, the neutral point moves toward it; but if the substance is diamagnetic it moves from it.

The same thing will happen, though in a less degree, in the case of a steel magnet, so that its neutral point depends on external conditions as well as on internal.

We now come to practically the most interesting case of distribution, namely, that of a straight bar magnetized longitudinally either by a helix around it, or by placing it in a magnetic field parallel to the lines of force; we shall also see that this is the case of a steel magnet magnetized permanently. This case is the one considered by Biot (Traité de Phys., tome iii. p. 77) and Green (Mathematical Papers of the late George Green, p. 111, or Maxwell's "Treatise," art. 439), though they apply their formulæ more particularly to the case of steel magnets. Biot obtained his formula from the analogy of the magnet to a Zamboni pile or a tourmaline electrified by heat. Green obtained his for the case of a very long rod placed in a magnetic field parallel to the lines of force, and, in obtaining it, used a series of mathematical approximations whose physical meaning it is almost impossible to follow. Prof. Maxwell has criticised his method in the following terms ("Treatise." art. 439):—"Though some of the steps of this investigation are not rigorous, it is probable that the result represents roughly the actual magnetization in this most important case." From the theory which I have given in the first part of this paper we can deduce the physical meaning of Green's approximation, and these are included in the hypotheses there given, seeing that when my formula is applied to the special case considered by Green, it agrees with it where the permeability of the material is great. My formula is, however, far more general than Green's.

It is to Green that we owe the important remark that the distribution in a steel magnet may be nearly represented by the same formula that applies to electro-magnets.

As Green uses what is known as the surface-density of magnetization, let us first see how this quantity compares with those I have used.

Suppose that a long thin steel wire is so magnetized in the direction of its length that when broken up the pieces will have the same magnetic moment. While the rod is together, if we calculate its effect on exterior bodies, we shall see that the ends are the only portions which seem to act. Hence we may mathematically consider the whole action of the rod to be due to the distribution of an *imaginary* magnetic fluid over the ends

of the rod. As any case of magnetism can be represented by a proper combination of these rods, we see that all cases of this sort can be calculated on the supposition of there being two magnetic fluids distributed over the surfaces of the bodies, a unit quantity of which will repel another unit of like nature at a unit's distance with a unit of force. The surface-density at any point will then be the quantity of this fluid on a unit-surface at the given point, and the linear density along a rod will be the quantity along a unit of length, supposing the density the same as at the given point.

Where we use induced currents to measure magnetism we measure the number of lines of force, or rather induction, cut by the wire, and the natural unit used is the number of lines of a unit-field which will pass through a unit-surface placed perpendicular to the lines of force. The unit-pole produces a unit-field at a unit's distance; hence the number of lines of force coming from the unit-pole is 4π, and the linear density is

$$\lambda=\frac{Q_\varepsilon}{4\pi\Delta L}, \qquad (11)$$

and the surface-density

$$\delta=\frac{Q_\varepsilon}{4\pi^2 d\Delta L}. \qquad (12)$$

These really apply only to steel magnets; but as in the case of electro-magnets the action of the helix is very small compared with that of the iron, especially when it is very long and the iron soft,* we can apply these to the cases we consider.

Transforming Green's into my notation, it gives

$$\lambda=\left(\frac{\pi d^2}{4}\right)\mathfrak{H}\varkappa r\frac{\varepsilon^{r(b-x)}-\varepsilon^{rx}}{1+\varepsilon^{rb}}, \qquad (13)$$

in which $\varkappa$ is Neumann's coefficient of magnetization by induction, and is equal to

$$\frac{\mu-1}{4\pi}$$

This equation then gives

$$Q'_\varepsilon=\Delta L\left(\frac{\pi d^2}{4}\right)\mathfrak{H}r(\mu-1)\frac{\varepsilon^{rx}-\varepsilon^{r(b-x)}}{1+\varepsilon^{rb}}. \qquad (14)$$

Equation (5) can be approximately adapted to this case by making $s'=\infty$, which is equivalent to neglecting those lines of force which pass out of the end section of the bar. This gives $A'=-1$, hence

* I take this occasion to correct an error in Jenkin's "Textbook of Electricity," where it is stated that, by the introduction of the iron bar into the helix, the number of lines of force is increased 32 times. The number should have been from a quite small number for a short thick bar and hard iron to nearly 6000 for a long thin bar and softest iron.

$$Q'_\epsilon = \Delta L \frac{\mathfrak{H}}{\sqrt{RR'}} \frac{\epsilon^{r(b-x)} - \epsilon^{rx}}{1+\epsilon^{rb}}. \quad . \quad . \quad . \qquad (15)$$

Now we have found (equation 7) that $r=\frac{2}{d}\sqrt{\frac{1}{\pi\mu R'}}$ nearly, and this in Green's formula (equation 14) gives

$$Q'_\epsilon = \Delta L \frac{\mathfrak{H}}{\sqrt{RR'}} \frac{\mu-1}{\mu} \frac{\epsilon^{rx} - \epsilon^{r(b-x)}}{1+\epsilon^{rb}}, \quad . \quad . \qquad (16)$$

which is identical with my own when μ is large, as it always is in the case of iron, nickel, or cobalt at ordinary temperatures.

When x is measured from the center of the bar, my equation becomes

$$\lambda = \frac{\mathfrak{H}}{4\pi\sqrt{RR'}} \frac{\epsilon^{rx} - \epsilon^{-rx}}{\epsilon^{\frac{rb}{2}} + \epsilon^{-\frac{rb}{2}}}. \quad . \quad . \quad . \qquad (17)$$

The constant part of Biot's formula is not the same as this; but for any given case it will give the same distribution.

Both Biot and Green have compared their formulæ with Coulomb's experiments, and found them to represent the distribution quite well. Hence it will not be necessary to consider the case of steel magnets very extensively, though I will give a few results for these farther on.

At present let us take the case of electro-magnets.

For observing the effect of the permeability, I took two wires 12·8 inches long and ·19 inch in diameter, one being of ordinary iron and the other of Stub's steel of the same temper as when purchased. These were wound uniformly from end to end with one layer of quite fine wire, making 600 turns in that distance.

In finding λ from Q''_ϵ, the latter was divided by $4\pi\Delta L$, except at the end, where the end section was included with ΔL in the proper manner. x was measured from the end of the bar in inches.

TABLE XI. Iron Electro-magnet.

x=distance from end.	Q_ϵ. Observed.	$4\pi\lambda$. Observed.	$4\pi\lambda$. Computed.	Error.
0				
	22·5	41·1	33·9	−7·2
½				
	12·6	25·1	26·9	+1·8
1				
	19·3	19·3	18·9	−0·4
2				
	12·0	12·0	11·7	− ·3
3				
	6·6	6·6	7·1	+ ·5
4				
	3·9	3·9	4·0	+ ·1
5				
	2·9	2·9	1·7	−1·2
6				

$4\pi\lambda=42.$

The observations in Table XI. are the mean of four observations made on both ends of the bar and with the current in both directions.

The agreement with the formula in this table is quite good; but we still observe the excess of observation over the formula at the end, as we have done all along. Here, for the first time, we see the error introduced by the method of experiment which I have before referred to in the *apparently* small value of $4\pi\lambda$ at $x = \cdot75$.

On trying the steel bar, I came across a curious fact which, however, I have since found has been noticed by others. It is that when an iron or steel bar has been magnetized for a long time in one direction and is then demagnetized, it is easier to magnetize it again in the same direction than in the opposite direction. The rod which I used in this experiment had been used as a permanent magnet for about a month, but was demagnetized before use. From this rod five cases of distribution were observed: first, when the bar was used as an electro-magnet with the magnetization in same direction as the original magnetism; second, ditto with magnetization contrary to original magnetism; third, when used as a permanent magnet with magnetism the same as the original magnetism; fourth, ditto with magnetism opposite; and fifth, same as third but curve taken after several days. The permanent magnetism was given by the current.

TABLE XII. Stub's Steel.

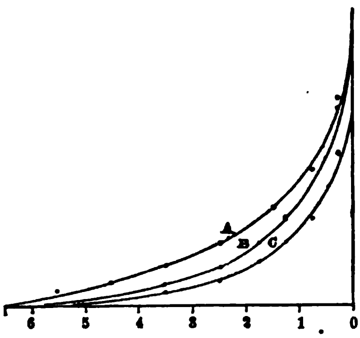
x.	Electro-magnet.				Permanent magnet.					
	Magnetism same as original.		Magnetism opposite to original.		Magnetism same as original.		Magnetism. opposite to original.		Ditto third After three or four days.	
	Q_e.	$44\pi\lambda$.	Q_e.	$4\pi\lambda$.	Q_e.	$\pi\lambda$.	Q_e.	$4\pi\lambda$.	Q_e.	$4\pi\lambda$.
0										
	23·3	42·5	15·9	29·0	14·4	13·7	4·8	4·6	12·8	12·2
½										
	11·5	23·0	7·7	15·4						
1										
	8·2	16·4	5·9	11 8	8·2	8·2	4·0	4·0	7·3	7·3
1½										
	6·1	12·2	4·3	8·6						
2										
	7·4	7·4	5·5	5·5	5·3	5·3	2·9	2·9	4·8	4·8
3										
	3·6	3·6	2·7	2·5	3·0	3·0	1·6	1·6	2·9	2·9
4										
	1·7	·8	1·0	·5	2·2	1·1	·9	·4	2·0	1·0
6										

The observations in Tables XI and XII. can be compared together, the quantities being expressed in the same unknown arbitrary unit. It is to be noted that the bars in Tables XI. and XII. were subjected to the same magnetizing-force.

First of all, from these tables and figures we notice the change in distribution due to the quality of the substance;

thus in fig. 5 we see that the curves for steel are much more steep than that of iron, and would thus give greater values to r in the formula, a result to be expected. We also observe in both figures the great change in distribution due to the direction of magnetization. In the case of the electro-magnet this amounts to little more than a change in scale; but in the permanent magnet there is a real change of form in the curve. It seems probable that this change of form would be done away with by using a sufficient magnetizing-power or magnetizing by application of permanent magnets; for it is probable that the fall in the curve E is due to the magnetizing-force having been sufficient to change the polarity completely at the center, but only partially at the ends.

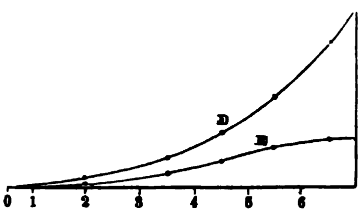
5.



Results from electro-magnets:—
A. Iron, from Table XI.
B. Steel, from Table XII, magnetized same as originally.
C. Steel, from Table XII, magnetized opposite to its original magnetism.

On comparing the distribution on electro-magnets with that on permanent magnets, we perceive that the curve is steeper toward the end in electro-magnets than in permanent magnets. At first I thought it might be due to the direct action of the helix, but on trial found that the latter was almost inappreciable. I do not at present know the explanation of it.

6.



Results from steel permanent magnets:
D. Magnetized in its original direction, Table XII.
E. Magnetized opposite to its original direction, Table XII.
Scale four times that of fig. 5.

As before mentioned, Coulomb has made many experiments on the distribution of magnetism on permanent magnets, and so I shall only consider this subject briefly. I have already given one or two results in Table XII.

The following tables were taken from two exactly similar Stub's steel rods not hardened, one of which was subsequently used in the experiments of Table XII. They were 12·8 inches long and ·19 inch in diameter.

The coincidence of these observations with the formula is very remarkable, but still we see a little tendency in the end observation to rise above the value given by the formula.

TABLE XIII.

x.	Q_e. Observed.	$4\pi\lambda$. Observed.	$4\pi\lambda$. Computed.	Error.
0				
	46·6	34·9	34·26	+·6
1·28				
	23·8	18·6	18·60	0
2·56				
	12·6	9·8	9·88	—·1
3·84				
	7·2	5·6	4·77	+·8
5·12				
	2·3	1·8	1·41	+·4
6·40				

$$4\pi\lambda = \cdot 117(10^{\cdot 203(b-x)} - 10^{\cdot 203x}).$$

In equation (7), and also from Green's formula, we have seen that for a given quality and temper of steel $\frac{rd}{2}$ is a constant. From Coulomb's experiments on a steel bar ·176 inch in diameter whose quality and temper is unknown, though it was

TABLE XIV.

x.	Q_e. Observed.	$4\pi\lambda$. Observed.	$4\pi\lambda$. Computed.	Error.
0				
	42·6	31·9	30·74	+1·2
1·28				
	21·4	16·7	16·72	0
2·56				
	10·9	8·5	8·86	— ·4
3·84				
	5·4	4·2	4·28	— ·1
5·12				
	1·7	1·33	1·27	+ ·1
6·40				

$$4\pi\lambda = \cdot 105(10^{\cdot 203(b-x)} - {}^{\cdot 203x}).$$

probably hardened, Green has calculated the value of this constant and obtained ·05482, which was found from the French inch as the unit of length, but which is constant for all systems. From Tables XIII. and XIV. we find the value of r to be ·4674, whence $\frac{rd}{2} = \cdot 04440$ for steel not hardened. As the steel becomes harder, this quantity increases and can probably reach about twice this for *very* hard steel.

TABLE XV.

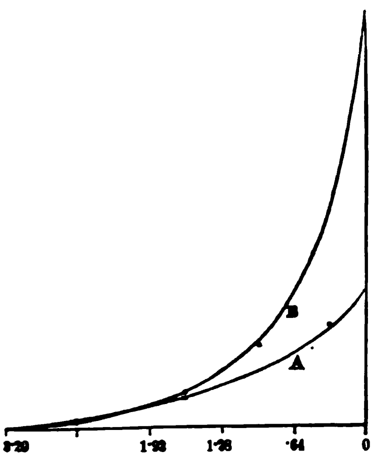
x.	Soft steel, A.		Hard steel, B.	
	Q_e.	$4\pi\lambda$.	Q_e.	$4\pi\lambda$.
0				
	20·4	29·1	47·7	68·1
·64				
	9·8	15·3	13·9	21·7
1·28				
	6·0	9·4	7·0	11·0
1·92				
	3·8	3·0	2·6	2·0
3·20				

To show the effect of hardening, I broke the bar used in Table XIV. at the center, thus producing two bars 6·4 inches

long. One of these halves was hardened till it could scarcely be scratched by a file, but the other half was left unaltered. The following table gives the distribution, using the same unit as that of Tables XIII. and XIV. The bars were so short that the results can hardly be relied on; but they will at least suffice to show the change.

In fig. 7 I have attempted to give the curve of distribution from Table XV, and have made the curves coincide with observation as nearly as possible, making a small allowance, however, for the errors introduced by the shortness of the bar. It is seen that the effect of hardening in a *bar of these dimensions* is to increase the quantity of magnetism, but especially that near the end. *Had the bar been very long, no increase in the total quantity of magnetism would have taken place, but the distribution would have been changed.* Hence from this we deduce the important fact *that hardening is most useful for short magnets. And it would seem that almost the only use in hardening magnets at all is to concentrate the magnetism and to reduce the weight.* And indeed I have made magnets from iron wire whose magnetization at the central section was just as intense as in a steel wire of the same size; but to all appearances it was less strongly magnetized than the steel because the magnetism was more diffused; and as the magnetism was not distributed so nearly at the end as in the steel, its magnetic moment and time of vibration was less.

7.



Results from permanent magnets.
A. Soft steel.
B. Hard steel.

It is for these reasons that many makers of surveyors' compasses find it unnecessary to harden the needles, seeing that these are long and thin.

We might deduce all these facts from the formulæ on the assumption that r is greater, the harder the iron or steel.

Having thus considered briefly the distribution on electromagnets and steel magnets, and found that the formulæ represent it in a general way, we may now use them for solving a few questions that we desire to know, though only in an approximate manner.

[To be continued.]

ART. III.—*On Recent Researches in Sound;* by WM. B. TAYLOR.

THAT two so eminent physicists as Professor Tyndall in England, and Professor Henry in our own country, should have been for some time past (and almost simultaneously) engaged in investigating the aberrant actions of Sound, with especial reference to securing increased efficiency to the national systems of Fog-signaling, is a noteworthy circumstance, and one of no slight practical importance. In view of the many disastrous marine accidents resulting from fogs on either coast, every thoughtful mind must regard with profound interest a series of researches requiring so much patient labor for the attainment of new and accurate information on the subject, and so high a degree of scientific sagacity and skill for its right interpretation.

As somewhat different explanations have been offered by these two distinguished observers to account for certain abnormal phenomena of sound, a concise statement of the facts and views respectively announced, will interest the general reader. The records of these investigations are, on the one side, the Philosophical Transactions of the Royal Society of London for the year 1874, vol. clxiv, page 183, "On the Atmosphere as a Vehicle of Sound," by John Tyndall, LL.D., F.R.S., a communication read February 12, 1874; and on the other side, the Annual Report of the Light House Board of the United States for the year 1874; the Appendix to which is an account of the operations of the Board relative to Fog-Signals, by Joseph Henry, Chairman of the Light House Board. In addition to these principal sources of information, reference will be made to an interesting communication read before the Royal Society, April 23, 1874, "On the Refraction of Sound," by Professor Osborne Reynolds, and published in the Proceedings of the Royal Society for 1874. The salient points of the observations are selected, and are here arbitrarily designated by bracketed numbers, to facilitate comparisons.

I.

Ten years ago, or in 1865, Professor Henry commenced his investigations on the subject of Sound in connection with fog-signals, at the Light House station near New Haven, Connecticut. Omitting here his careful experiments in regard to the character of the various instruments employed, the principal results then obtained, were the following:

[1.] The reflection of sound was observed to be very imperfect and inexact. A large concave reflector with a smoothly

plastered surface of 64 square feet, produced a sensible increase of effect in the sound, within a distance of 500 yards in front of the signal: beyond this distance, the difference became imperceptible. It appeared that "while feeble sounds at small distances are reflected as rays of light are, waves of powerful sound spread laterally, and even when projected from the mouth of a trumpet, at a great distance tend to embrace the whole circle of the horizon." (L. H. Rep., p. 88.) A trumpet, however, which could be heard six miles in front (in the direction of the axis) was heard only three miles in the rear. (p. 92.)

[2.] "For determining the relative power of the instruments, the use of two vessels had been obtained." The instruments at the light-house station were a large bell, a steam-whistle 6 inches in diameter, a double whistle, "improperly called a steam gong," 12 inches in diameter, the cups being 20 and 14 inches deep, producing the harmonic interval of a tone and its fifth, and a Daboll trumpet operated by a hot air engine. The blow-off sound from the "exhaust" of the air engine was also noted. "The penetrating power of the trumpet was nearly double that of the whistle." (Rep., p. 90.) The order of audible range on the first day was found to be 1st, trumpet, 2nd, exhaust, 3rd, bell, the whistle not being sounded. On the second day, 1st, trumpet and "gong," 2nd, whistle, 3rd, exhaust. In the rear the trumpet was heard no farther than the whistle. On the third day, the order was similar,—1st, trumpet, 2nd, whistle, 3rd, exhaust, 4th, bell. (p. 91.) The opportunity was unfavorable to the observation of these sounds when they were moving directly with the wind.

[3.] Simultaneous observations from two vessels sailing in nearly opposite directions, showed that the sound did not extend against the wind so far as in the direction of the wind; and on subsequent days, results obtained from sounds moving nearly against the wind, and at right-angles to it, indicated that an opposing wind, when light, obstructed sound less than when stronger, and that wind at right-angles to the sound, permitted it to be heard farther. (Rep., p. 92.)

[4.] "During this series of investigations an interesting fact was discovered, namely, a sound moving against the wind, inaudible to the ear on the deck of the schooner, was heard by ascending to the mast-head." (p. 92.) These results were obtained in 1865.

[5.] An experiment subsequently made at Washington during a fog, with a small clock-work alarm bell, indicated that the fog did not absorb sound; though want of the opportunity of a comparative observation prevented the result from being entirely satisfactory. (p. 93.)

In 1867, the principal object of investigation was a compari-

son of different instruments, the character and value of the improvements made in them and especially an examination of a new fog-signal made under the direction of the Board by Mr. Brown, of New York,—the steam siren (p. 194), an inctrument which has since played an important part in fog-signaling. Employing 1st a large Daboll trumpet, 17 feet long, (its steel tongue being 10 inches long), and operated by a hot air engine, 2nd, a siren operated by a tubular steam boiler, and 3rd, a steam whistle, 8 inches in diameter,—an elaborate series of experiments was made as to their penetrating power, as to the most efficient pitch or tone, (p. 95), the effect of varying steam pressure from 20 pounds per square inch to 100 pounds per square inch, (p. 97), the material and shape of the trumpets, &c. (p. 98.)

[6.] During this series of experiments in 1867, attention was called by General Poe, of the Light House Board, to the circumstance that the sound of the paddle-wheels of a steamer some four and a half miles distant from the shore could be distinctly heard by bringing the ears near to the surface of the beach. This fact had previously been noticed on the northern lakes. The desirability of experimenting with large hearing trumpets placed near the surface of the water is suggested by Professor Henry. (p. 98.)

[7.] Experiments on the divergence of acoustic beams, while indicating a considerable reduction of sound toward the rear of the trumpet, showed also very strikingly, the increasing tendency of sound to spread on either side of the axis of the trumpet. (p. 98.) This corresponds with the observations [1] on the employment of sound reflectors.

An important suggestion is made, requiring experimental determination, namely, that condensed air would probably give more efficient results to both the fog-whistle and the siren, than steam. "From hypothetical considerations this would appear to be the case, since the intensity of sound depends on the density of the medium in which it is produced; and as the steam is considerably lighter than air, and as the cavities of all these instruments are largely filled with steam, the intensity of sound would on this account seem to be less." (Rep., p. 99.)

In the absence of Professor Henry in England in 1870, experiments were continued by General Duane, one of the Light House District engineers. These will presently be noticed.

[8.] In 1872 Professor Henry observed from a steamer in the harbor of Portland, Maine, that while approaching an island from which a fog-signal was audible,—at the distance of two or three miles, the sound was lost for nearly a mile, and then slightly regained at nearer approach. This was partly in the rear of the signal; and from its position on the farther side of

the island from the steamer, with a large house and rising ground interposed, Professor Henry infers that the region of inaudibility was covered by an acoustic shadow, encroached upon at a greater distance by the divergence of the rays of sound, which, bending, reached ultimately the surface of the water. (p. 107.) A similar phenomenon was observed in the same year on approaching Whitehead station near the coast of Maine. The fog-signal was heard from the distance of six miles to about three miles, and then lost until within a quarter of a mile. (p. 107.) Again, at little Gull Island, in a vessel receding from the siren signal in the direction of its trumpet axis, the sound was lost at a distance of two miles, and then regained at a distance of four and a half miles. (p. 111.) These last cases are referred by Professor Henry to a flexure of the rays of sound resulting from differences of wind velocity in the upper and lower strata of air.

[9.] In 1872, it was observed that a fog-signal was heard from one station to another, while a simultaneous signal from the latter was inaudible in the opposite direction. On board a steamer approaching Whitehead station (a mile and a half from the coast of Maine), the signal, a steam-whistle, failed to be heard from the distance of about three miles to about a quarter of a mile from the station: while a smaller whistle on the steamer was distinctly heard by the keeper at the station during that time. The wind was slightly transverse to the direction from the steamer to the station, but approximately in that direction. The steamer after stopping at the station, on passing from it almost directly against a light wind, continued to hear the signal with variable distinctness for about fifteen miles. (p. 108.) In September, 1874, the keeper at Block Island, on the coast of Rhode Island, observed according to instructions, the times when the fog-signal from Point Judith at a distance of seventeen miles was audible, and in comparing the times when the Block Island signal (a powerful steam siren) was heard at Point Judith, it appeared that the two sounds had not been heard simultaneously by the two keepers. (p. 112.)

[10.] In August, 1873, at Cape Elizabeth station in Maine, the phenomenon of ocean-echoes was distinctly noticed on board a steamer as it was passing directly outward from the signal; the sound after each whistle being returned from the unobstructed space beyond. (p. 109.) In September, 1874, at Black Rock Island also, shortly after each blast of the trumpet, a prolonged echo from the open ocean was distinctly heard. The echo was observed not to be loudest at the siren-house, but at a point several hundred yards to one side; the wind being in the direction of the primitive sound, and nearly opposite to the direction of the reflected echo. (p. 112.) This was supposed by Professor

Henry to be caused by a reflection of the sound from the crests and slopes of the waves.

[11.] On September 23rd, 1874, three observations were made on board steamers moving in opposite directions about one and a half miles from Sandy Hook, New Jersey. First, before noon with the wind from the west, second, at noon with the wind lulled to a calm, and third, an hour and a half later, with the wind blowing from the east. These observations gave the unexpected result of the sound being heard in each case uniformly farthest from the west, irrespective of the wind. (p. 114.) On the next day, September 24th, the observations were repeated farther out at sea, or six miles from the nearest land. Small balloons, sent off with each observation on the sound, showed that notwithstanding the change of surface wind as before, from morning to afternoon, the upper current of wind was steadily and continuously from the west. (p. 115.) Professor Henry supposes that in the first case "the motion of the air being in the same direction both below and above, but probably more rapid above than below on account of resistance, the upper part of the sound-wave would move more rapidly than the lower, and the wave would be deflected downward, and therefore the sound as usual heard farther with the wind than against it." In the third case with a local sea-breeze in the opposite direction, and the upper current remaining unchanged, "the sound should be heard still farther in the same direction or against the wind at the surface, since in this case the sound-wave being more retarded near the surface, would be tipped over more above, and the sound thus thrown down." (p. 115.) This explanation derived from a communication of Professor Stokes, at the Dublin Meeting of the British Association in 1857, (Rep. of B. A., 1856, p. 22 of Abstracts) would appear to be a very satisfactory solution of the apparent anomaly.

II.

In 1870, General Duane, the engineer in charge of the Light-house District embracing the coast of Maine, New Hampshire, and Massachusetts, was assigned by the Light House Board, (as one "who from his established reputation for ingenuity and practical skill in mechanism, was well qualified for the work,") to make experiments and observations on fog-signals. Accordingly during the year 1871, extensive investigations were made by him at Portland, Maine. Passing over his valuable remarks on the qualities of fog-signals, the following are the principal facts observed by him:

[A.] The extremely variable range of sound. The steam fog-whistles on the coast of Maine could frequently be heard at a distance of twenty miles, and as frequently could not be heard

two miles, with apparently the same state of the atmosphere. (L. H. Rep., p. 100.)

[B.] The signal was often heard at a great distance in one direction, while scarcely audible at a mile in another direction, and this quite irrespective of the wind. (p. 100.)

[C.] Falling snow was observed not to obstruct sound sensibly, as the steam-whistle on Cape Elizabeth can be "distinctly heard in Portland, a distance of nine miles, during a heavy northeast snow-storm, the wind blowing a gale directly from Portland toward the whistle." (p. 100.)

[D.] The signal station frequently "appears to be surrounded by a belt varying in radius from one to one and a half miles, from which the sound appears to be entirely absent." Receding from the signal, its sound may be audible for the distance of a mile, then lost for the distance of a second mile, and then audible again for a much farther distance. This abnormal phenomenon has been observed at various stations, and at one where the signal is on a bare rock in mid-ocean, twenty miles away from land, and with no surrounding objects to affect the sound. (p. 100.)

No observations have been made to show that this occasional sound-chasm is really a "belt" entirely surrounding the signal; a supposition which appears to be antecedently improbable, and one which would require a large number of radiating observations made simultaneously, to establish it. The curious and exceptional fact, however, is confirmed by the observations of Henry [8] made subsequently.

[E.] Confirmatory of Henry [1], General Duane found that a whistle in the focus of a large parabolic reflector, though giving a notably louder sound in front near the reflector, yet at the distance of a few hundred yards, had its beam of sound so spread that the acoustic shadow behind the mirror vanished, and no perceptible difference appeared. A wooden trumpet or square pyramidal box 20 feet long, in a horizontal position with the whistle in the smaller end, gave, however, more successful results, the increase of sound in the open axis being perceptible at the distance of a mile. (Rep., p. 103.) This corresponds also with Henry's observation [7].

[F.] In repetition and explanation of observation [A] General Duane remarks: "It frequently occurs that a signal which under ordinary circumstances would be audible at the distance of fifteen miles, cannot be heard from a vessel at the distance of a single mile. This is probably due to the reflection mentioned by Humboldt." (p. 104.) This great traveller and scientific observer, in his graphic narrative of exploration in the northern part of South America published at the beginning of the century, ascribes the diminished audibility during the day,

of the noise from the cataracts of the Orinoco, at a place on the Atures, to the unequal heating of the air and the reflection and dispersion of the sound from the surfaces of the striæ of differing density.

[G.] It was further noticed by General Duane that "when the sound is thus impeded in the direction of the sea, it has been observed to be much stronger inland;" tending to confirm his idea that the sound in passing from a warmer to a cooler region of air "undergoes reflection at their surface of contact." (p. 104.)

Professor Henry dissents from this opinion that the extinction of powerful sounds is due to unequal density of the atmosphere. Admitting that "a slight degree of obstruction of sounds may be observed" from such a condition, he thinks it "entirely too minute to produce the results noted." (p. 104.) He believes that the "true and sufficient cause" is the difference between the upper and lower currents of air, which tends to bend the sound rays either upward or downward, as suggested by Professor Stokes in 1857. He adds, "In the comments we have made on the Report of General Duane the intention was not in the least to disparage the value of his results which can scarcely be too highly appreciated." (Rep., p. 106.)

[H.] A difficulty occasionally observed with vessels in a fog, is an apparently false direction of the audible signal; which General Duane regards as "due to the *refraction* of sound in passing through media of different density." (p. 104.)

[I.] While thus adopting "the conclusion that these anomalies in the penetration and direction of sound from fog-signals, are to be attributed mainly to the want of uniformity in the surrounding atmosphere," General Duane was also led from observation and experiments to believe "that snow, rain, fog, and the force and direction of the wind, have much less influence than has generally been supposed." (p. 104.) This is in confirmation of his previous observation [C].

III.

Professor Tyndall commenced his investigations on fog-signals on the 19th of May, 1873, "at the instance of and in conjunction with the elder brethren of the Trinity House," as the scientific adviser of the Corporation.

[1.] On May 20, 1873, observations showed the relative penetrating power of different instruments to be variable. At six miles the fog-horn was inaudible, while an eighteen pound gun with three pound charge was heard for ten miles. On many subsequent occasions the horn was found to be superior to the gun. (*Trans. R. S.*, p. 188.) Occasionally the whistles were superior to the trumpet, though not generally so. (p. 189.)

Later experiments in October showed that the pitch of the sound had variable penetration on different days and even at different times on the same day. The siren (an American instrument lent by the United States Lighthouse Board, and put in use October 8, 1873) was generally decidedly triumphant, but not always so. (*Trans.*, pp. 220, 221.)

[2.] The defect of sound in the acoustic shadow of an intervening obstacle (a chalk cliff) was very strikingly manifested. In June the same sharpness of shadow line was observed; and even with the instruments in view, at the distance of a mile, their sound entirely failed near the shadow line at one side. (*Trans.*, p. 190.)

[3.] Although "the wind exerts an acknowledged power over sound" yet, on the 25th of June, "when the range was only six and a half miles, the wind was favorable; on the 26th when the range exceeded nine and a quarter miles, it was opposed to the sound." (p. 194.) On October 11, the sound was observed to be much affected by an adverse wind. It was also noticed on this as well as on subsequent occasions, that "an opposing wind affects the gun-sound far more seriously than that of the siren." With a favoring wind, sounds were heard twice as far as with an adverse wind, even at a point "more deeply immersed in the sound-shadow." (p. 224.)

[4.] July 1, at a distance of five and a quarter miles from a rotating horn it was observed that the sound was sensibly stronger in front than at the rear of the trumpet, the reduction being estimated as seven to ten. (p. 192.)

[5.] July 1, "In a thick haze, the sound reached a distance of twelve and three-quarter miles, while on May 20, in a calm and hazeless atmosphere, the maximum range was only from five to six miles." (p. 193.) And subsequent observations made in London, December 10 and 11, showed that a thick fog offered no sensible obstruction to the passage of sound. (p. 209, 210.)

[6.] On July 3, at 2.15 P. M. "with a calm clear air and smooth sea," at three miles from the signal station "neither horn nor whistle was heard. The guns were again signaled for; five of them were fired in succession, but not one of them was heard." (p. 194, 195.) As a hot sun was pouring its beams on the sea, Professor Tyndall supposed that the copious evaporation resulting, would most probably act very irregularly, producing streams or wreaths of vapor, and thus render the air *flocculent* with these invisible cloudlets, whose surfaces would occasion a large amount of repeated reflection and dispersion of the sound waves. As the sun afterward became clouded at 3.15 P. M., the sounds of the signal were heard at three miles, and very faintly at four and a quarter miles; and later at six miles, and

seven and three-quarter miles. Toward the close of the day the signals were heard at twelve and three-quarter miles. (p. 196, 197.)

[7.] On the same day at one o'clock, the echoes from the direction of the open sea were very distinct at the signal station. "The instruments hidden from view, were on the summit of a cliff 235 feet above us, the sea was smooth and clear of ships, the atmosphere was without a cloud, and there was no object in sight which could possibly produce the observed effect. From the perfectly transparent air, the echoes came, at first with a strength apparently but little less than that of the direct sound, and then dying gradually and continuously away." (p. 198.) These remarkable echoes are supposed by Professor Tyndall to be returned from the invisible surfaces of the vaporous striæ, which thus render the air opaque to the sonorous waves. Subsequently, on the 8th of October, the American siren being just received and set up, its loud echoes were observed to be "far more powerful than those of the horn," and to last eleven seconds, while those of the horn had eight seconds duration. (p. 199.) On the 15th of October, the direction of the echoes was found to correspond with the principal axis of the direct or primitive sound; the direction of the return sound changing with the rotation of the horn. (p. 200.)

[8.] On October 8th rain and hail were found not to obstruct sound. While in the morning (after a thunder storm) from Dover and the South Foreland across the English channel "for a time the optical clearness of the atmosphere was extraordinary, the coast of France, the Grisnez lighthouse, and the Monument and Cathedral of Boulogne being clearly visible in positions from which they were generally quite hidden; the atmosphere at the same time was acoustically opaque;" and the horn was feebly heard at six miles. (p. 205.) But in the afternoon a storm arose, and although the rain was falling heavily all the way between the signal station at Foreland and the point of observation on the steamer, "the sound instead of being deadened, rose perceptibly in power. Hail was now added to the rain, and the shower reached a tropical violence." "In the midst of this furious squall both the horns and the siren were distinctly heard," and as the shower lightened, diminishing the local pattering on the deck, they were heard "at a distance of seven and a half miles distinctly louder than they had been heard through the rainless atmosphere at five miles." (p. 206.) On the 23d of October, a similar experience was noticed on land, and, contrary to the usual impression, snow was also observed to offer no serious obstacle to sound. (p. 207.)

It must be borne in mind that the investigations by Professor Tyndall were concluded before the publication of the United States Lighthouse Report. And it is noticeable that these two series of original observations thus independently made on the opposite sides of the Atlantic, in the main quite strikingly confirm each other.

Tyndall's notice [1] of the inconstant relative range of different instruments corresponds with Henry (2), though indicating a much more marked variability.

Tyndall's notice [2] of the sound shadow, corresponds generally with Henry [7], and Duane [E], but assigns a sharper definition to its limit; probably in consequence of the intervention of a larger obstacle (a cliff), and an observation within a shorter distance.

Tyndall [3] confirms Henry [3] and [11].

Tyndall [4] corresponds with Henry [7] and Duane [E].

Tyndall [5] confirms by a series of careful observations, the opinion of Henry [5] and Duane [I].

Tyndall [6] confirms Duane [A and F], and in like manner adopts and extends the suggestion of Humboldt as to the cause of acoustic opacity. Professor Tyndall's admirable skill in experimental physics enabled him to illustrate and fortify his hypothesis by exhibiting in a popular lecture an apparatus for producing in an elongated box or tunnel, aerial laminæ of unequal density, through which the sound from a small alarm box failed to excite a sensitive flame. That this mottled condition of the air is therefore a true cause of acoustic obstruction is no longer doubtful. To what extent a similar condition of the atmosphere actually prevails, in view of the law of the diffusion of gases, and how far such usual or unusual inequalities of density in the air are capable of entirely dispersing the powerful sound of a steam trumpet or siren, at the distance of a quarter of a mile, are not so positively determined. With a continuous wind any such condition of aerial "flocculence" might be expected to be very speedily dissipated.

This theory, however, fails entirely to explain the interesting observations of Henry [4, 8, and 9]. It is scarcely credible that a local screen of aerial flocculence could obliterate on the deck of a schooner, a fog-signal audible at the mast-head. Atmospheric refraction on the other hand, completely satisfies the observed condition; an opposing wind blowing at the time. Still less successful is the theory, in dealing with the abnormal phenomenon of simultaneous audibility at long range, with the intermediate "belt" of acoustic opacity, first observed by Duane [D]. And lastly, the assumption of simultaneous transmission of sound *through* a flocculent air-screen in one direction and its absorption or dissipation by the screen in the opposite

direction, (acoustic "non-reversibility,") is obviously inadmissible. Nor is the supposition of acoustic "diffraction" around the defined edge of a vapor cloud, more available.

Professor Tyndall in his recent Preface to the last edition of "Sound" remarks upon this observation of Henry [9]—"a sufficient reason for the observed non-reciprocity is to be found in the recorded fact that the wind was blowing against the shore-signal, and in favor of the ship-signal." (*Preface*, p. xxi.) But he offers no suggestion how this "sufficient reason" is supposed to apply. As it is well-known that an ordinary wind cannot increase the range of sound more than two or three per cent (an amount quite inappreciable), this circumstance alone is wholly inadequate to account for the complete suppression of the shore-signal (a ten-inch steam-whistle) from the distance of three miles to *a quarter of a mile*, while the feebler sound of the ship-signal (a six-inch steam-whistle) was making itself distinctly heard throughout the three miles. Something more therefore than the direct or convective action of the wind must be invoked to explain the facts.

Tyndall's observation [7] on the aerial or ocean echoes, corresponds with Henry [10] excepting as to the direction of the principal echo. This difference is doubtless due to the special arrangement of the surfaces or points of reflection in the respective cases observed. Professor Tyndall connects this phenomenon with that of acoustic opacity [6]; and here again his fine experimental skill is brought into requisition to demonstrate the reality of artificial "aerial echoes." By so simple a device as the employment of the flat side of a "bat-wing" gas-jet, the sound beam from a reed instrument was shown to be entirely deflected from one sensitive flame, and reflected back toward another.

This view of a relation between the acoustic opacity outward or seaward, and the reinforcement or reflection of sound inward, is in striking accord with Duane [G], who however in referring to the "reflection" of sound, does not specifically allude to the ocean "echo." On the refraction theory also, a necessary result is that a deflection of the sound-beam upward in one direction, must be attended with a downward deflection and consequent increase of sound in the opposite direction.

Professor Henry had referred these mystic echoes to the crests and slopes of distant waves; (in conjunction probably with a curvature of the sound-beams, constituting a kind of acoustic "mirage.") To this suggestion, Professor Tyndall opposes the observation that "the echoes have often manifested an astonishing strength, when the sea was of glassy smoothness." (*Sound*, *Pref.*, p. xxiii.)

That this very interesting subject presents features requiring still further and more refined investigation is sufficiently obvious from the single consideration that aerial opacity and echo have not been shown to bear that direct relation which the vapor theory requires. Professor Tyndall has recorded that, on the 17th of October (1873), "It is worth remarking that this was our day of longest echoes, and it was also our day of greatest acoustic transparency, the association suggesting that the duration of the echo is a measure of the atmospheric *depths* from which it comes. On no day, it is to be remembered, was the atmosphere free from invisible acoustic clouds; and on this day when their presence did not prevent the direct sound from reaching to a distance of 15 or 16 nautical miles, they were able to send us echoes of 15 seconds duration." (*Trans.*, p. 202.) If these echoes were not "folded," this would represent an extreme limit of about a mile and a half. Our most powerful sounds cannot afford to waste much of their energy on echoes, if under the inexorable law of increasing attenuation as the square of the distance they are to be audible through a range of 16 miles: less than the 400th of the intensity at one nautical mile, that is heard at the distance of 100 yards from the source; and one 256th of this at the distance of 16 nautical miles, or less than the hundred thousandth of the intensity at 100 yards. And the inference is strong that in such a case accompanying echoes must be derived from sound beams in a somewhat different direction.

Further observations are needed also to ascertain whether these aerial screens of unequal density and acoustic opacity are capable of returning echoes on opposite sides, as is to be expected if we may accept the analogy of catoptrics: and whether the echoes are as frequently heard from steamers in mid-ocean, or whether they mainly attach themselves to coast lines. As Professor Henry has well stated: "Much farther investigation is required to enable us to fully understand the effects of winds on the obstruction of sound, and to determine the measure of the effect of variations of density in the air due to inequality of heat and moisture." (*L. H. Rep.*, p. 117.)

As the last of the series here selected, Tyndall's observation [8] agrees well with the observation of Duane [1].

[To be concluded.]

ART. IV.—*Effect of Temperature on the Power of Solutions of Quinine to rotate Polarized Light. The corrections to be applied for the same. Suggestions regarding the preparation to be used when Quinine is employed as a Medicine;* by JOHN C. DRAPER, Professor of Natural History, College of the City of New York.

IN an admirable article on "The Action of the Solution of certain Substances on Polarized Light," by O. Hesse, in the Annalen der Chemie for 1875, the writer after dealing at length with the varying action of the alkaloids on a beam of polarized light says: "If we now take into consideration the fact that transparent bodies, as water and alcohol, are able, under the influence of electro-magnetism to deflect the plane of polarized light, although this property does not otherwise belong to them; and that the optical powers of a substance can be influenced by mere mechanical means, as Scheibler has proved in certain kinds of glass; we must admit, that '*There is no real relation between the rotating power of a substance and its molecules.*'" He then adds, "The rotating power of a substance is simply the result of the variable action of its factors, viz: the arrangement of the molecules as regards the volume, the solvent, the temperature, the concentration, the chemical combination, the dissociation and other things."

The importance of utilizing the rotation power of quinine for the practical purposes of analysis has induced me to endeavor to determine, as far as possible, the corrections to be applied for the variations in question, and especially for those dependent on temperature. Concerning this, A. Bouchardat says, "variation in temperature causes variation in the rotation power of quinine." In the paper mentioned above, O. Hesse says, "in the case of Thebaine and Quinine the rotation diminishes under an increase of temperature;" but he afterward adds, "I found that the variation between 15° C. and 25° C. was insignificant."

In my experiments the polariscope employed belonged to my friend, Dr. R. A. Witthaus. It was made by Laurent, of Paris, and read by verniers to two minutes. The tube was of glass 220 millimeters in length, with a lateral aperture near the center, through which a thermometer was introduced for the determination of temperature. Around this tube I placed a water jacket, the temperature of which was easily raised to and kept at any required degree, by the injection of steam through a pipe which passed to the bottom of the jacket. Having satisfied myself by a series of experiments that extreme variations of temperature in the water of the jacket, or bath, did not produce

any appreciable effect upon the indications of the instrument itself, I proceeded to the determination of the rotation power of the purest sample of quinine I could procure.

Bearing in mind the statement quoted above, that the concentration, solvent and chemical combination have their influence on the amount of rotation, I assumed specific conditions for the preparation of the experimental solutions which might be easily reproduced. They were, 1st, the use of the uncombined alkaloid quinine, carefully dried over strong sulphuric acid, 2d, ninety-seven per cent alcohol as the solvent and a concentration proportion of one gram of quinine, to fifty cubic centimeters of the alcoholic solution. For the sake of convenience the factors required in calculating the results are presented in the following tabular arrangement, viz:

v. volume of 97 p. c. alcoholic solution = 50 cubic centimeters.
p. weight of quinine = 1 gram.
λ. length of tube = 220 millimeters.
α = angle of rotation observed with sodium flame.

The formula being $[\alpha]j = \frac{\alpha \times v}{\lambda \times p} \times 100$ and the average of 200 observations on four solutions at a temperature of 25° C. being $\alpha = -6{\cdot}789°$ we have

$$(1)\quad [\alpha]j = \frac{-6{\cdot}789° \times 50}{220 \times 1} \times 100 \text{ or}$$
$$[\alpha]j = -154{\cdot}30° \text{ at } 25° \text{ C.}$$

Raising the temperature to 47° C. the average of 200 observations on the same solutions as before was $\alpha = -6{\cdot}245°$ from which by the formula we have

$$(2)\quad [\alpha]j = \frac{-6{\cdot}245° \times 50}{220 \times 1} \times 100 \text{ or}$$
$$[\alpha]j = -141{\cdot}93° \text{ at } 47° \text{ C.}$$

The difference of temperature in (1) and (2) being 22° C. and the difference in the angle of rotation 12·37°, it follows that 1° C. = ·562° difference.

That is, in a solution of quinine of the strength in question, viz: 20 milligrams of alkaloid to one cubic centimeter of alcoholic solution, for each additional degree Centigrade of temperature the angle of rotation diminishes ·562 of a degree.

To ensure the correctness of these figures I caused my assistant, Mr. Ivan Sickels, also to carry out a series of experiments, and the result of seven hundred observations at temperatures between 25° C. and 47° C. gave figures which only differed in the third decimal place. We are therefore justified in employing the correction in question for values in the vicinity of 25°

C. which closely approaches the temperature at which such observations are made in actual practical work.

Effect of variation in the Proportion of Alcohol in the Solution.—Hesse having shown that the strength of the alcohol has a marked effect on the rotating power of quinine, it followed that perhaps variation in the proportion of quinine dissolved in a given specimen of alcohol would also give variation in the power of rotation. In the examination of this problem I employed a freshly prepared solution of one gram of undried quinine in 50 cubic centimeters of 97 per cent alcohol. The average of 100 readings of the angle of rotation at various temperatures from 20° C. to 50° C. was

$$(3) \quad \alpha = -6{\cdot}05° \text{ at } 35° \text{ C.}$$

To the above 50 cubic centimeter solution 50 cubic centimeters of the same alcohol were added, forming a solution of half the strength of the first solution. The average of 100 readings at similar temperatures was

$$(4) \quad \alpha = -2{\cdot}61° \text{ at } 36° \text{ C.}$$

To this second solution an equal volume of alcohol viz: 100 c. c. was added, giving a solution of one quarter the strength of the first. The average of 100 similar readings was

$$(5) \quad \alpha = -1{\cdot}27° \text{ at } 36° \text{ C.}$$

In the first solution (3) $p=1$ and $v=50$
In the second solution (4) $p=1$ and $v=100$
In the third solution (5) $p=1$ and $v=200$

By the formula $[\alpha]j = \frac{\alpha \times v}{\lambda \times p} \times 100$ we have

$$\text{For (3)} \quad [\alpha]j = \frac{-6{\cdot}05° \times 50}{220 \times 1} \times 100 = -137{\cdot}50° \text{ at } 35° \text{ C.}$$

$$\text{For (4)} \quad [\alpha]j = \frac{-2{\cdot}61° \times 100}{220 \times 1} \times 100 = -118{\cdot}64° \text{ at } 36° \text{ C.}$$

$$\text{For (5)} \quad [\alpha]j = \frac{-1{\cdot}27° \times 200}{220 \times 1} \times 100 = -115{\cdot}45° \text{ at } 36° \text{ C.}$$

From the above experiments we perceive that the effect of a dilution by alcohol of the solution of quinine is to lessen its power of rotation, and as far as the experiments have been conducted this effect is more marked in the first degree of dilution than in the second.

The repetition of these experiments by Dr. R. A. Witthaus and Mr. Sickels, on a similar series of solutions made with the same alcohol and an undried specimen of quinine, gave the following averages of many hundred readings.

In the 1st solution (6) $p=1 \cdot\cdot v=50 \cdot\cdot \lambda=220 \cdot\cdot \alpha=-5{\cdot}58°$ at 29° C.
In the 2d solution (7) $p=1 \cdot\cdot v=100 \cdot\cdot \lambda=220 \cdot\cdot \alpha=-2{\cdot}40°$ at 31° C.
In the 3d solution (8) $p=1 \cdot\cdot v=200 \cdot\cdot \lambda=220 \cdot\cdot \alpha=-1{\cdot}17°$ at 35° C.

By the formula $[\alpha]j=\frac{\alpha\times v}{\lambda\times p}\times 100$ we have

$$\text{For (6)}\quad [\alpha]j=\frac{-5{\cdot}58°\times 50}{220\times 1}\times 100=-126{\cdot}82° \text{ at } 29° \text{ C.}$$

$$\text{For (7)}\quad [\alpha]j=\frac{-2{\cdot}40°\times 100}{120\times 1}\times 100=-109{\cdot}09° \text{ at } 31° \text{ C.}$$

$$\text{For (8)}\quad [\alpha]j=\frac{-1{\cdot}17°\times 200}{220\times 1}\times 100=-106{\cdot}36° \text{ at } 35° \text{ C.}$$

Here again we perceive that the effect of dilution is to diminish the power of rotation, and to about the same extent and in the same manner as in my series of observations. It is therefore evident, that to secure results suitable for a reliable comparison, the solutions of quinine employed should be as nearly as possible of the same strength. The proportion which according to my experience it is most desirable to use is that of about one gram of alkaloid to 50 cubic centimeters of alcoholic solution. While a greater strength than this does not present any advantage in a tube of 220 millimeters, it is objectionable on account of its obstructing the passage of the light.

Quinine combined with Sulphuric Acid.—For the examination of this compound of quinine I prepared a solution which held the same proportion of quinine alkaloid in a given portion of the solution as that contained in the alcoholic solution. The solution was made by taking one gram of dried quinine, dropping it into about 30 cubic centimeters of distilled water, and adding just sufficient sulphuric acid to dissolve it.* The quantity was then made up to 50 centimeters with distilled water, and the 220 millimeter tube filled therewith.

At a temperature of 21° C. the average rotation as determined by 100 observations was $-11{\cdot}36°$. By the formula

$$[\alpha]j=\frac{\alpha\times v}{\lambda\times p}\times 100 \text{ we have}$$

$$\text{(9)}\qquad [\alpha]j=\frac{-11{\cdot}36°\times 50}{220\times 1}\times 100=-258{\cdot}18° \text{ at } 21° \text{ C.}$$

The temperature of the solution in the tube was then raised by means of the water jacket, and the average of 100 observations was $\alpha=-10{\cdot}73°$ at 43° C. By the formula

$$\text{(10)}\qquad [\alpha]j=\frac{-10{\cdot}73°\times 50}{220\times 1}\times 100=-243{\cdot}86° \text{ at } 43° \text{ C.}$$

* This solution was employed as being similar to that used by physicians.

The difference in temperature being 22° C. and the difference in rotation 14·32°, we have

1° C. = ·650° difference in rotation.

That is, for every rise of one degree Centigrade the rotation diminishes ·650 or nearly two thirds of a degree in a solution of sulphate of quinine in which there is one gram of alkaloid to 50 cubic centimeters of solution.

Effect of variation in the proportion of water.—A solution of sulphate in water prepared as before and containing one gram of alkaloid to 50 c. c. of solution when examined under a variety of temperatures, gave as the average result

(11) $\alpha = -11{\cdot}03°$ at $31\frac{1}{2}°$ C.

This solution diluted by an addition of 50 c. c. of distilled water by which v was raised from 50 to 100 gave under a similar variety of temperatures the average

(12) $\alpha = -5{\cdot}18°$ at 32° C.

Adding 100 c. c. of water to the last solution and thereby raising v to 200, gave under the same conditions

(13) $\alpha = -2{\cdot}58°$ at $31\frac{1}{2}°$ C.

Arranging these in a tabular form we have

For (11) $p=1 \cdot\cdot v=50 \cdot\cdot \alpha=-11{\cdot}03°$
For (12) $p=1 \cdot\cdot v=100 \cdot\cdot \alpha=-5{\cdot}18°$
For (13) $p=1 \cdot\cdot v=200 \cdot\cdot \alpha=-2{\cdot}58°$

From these by the formula $[\alpha]j = \frac{\alpha \times v}{\lambda \times p} \times 100$ we have

For (11) $[\alpha]j = \frac{-11{\cdot}03° \times 50}{220 \times 1} \times 100 = -250{\cdot}70°$ at $31\frac{1}{2}°$ C.

For (12) $[\alpha]j = \frac{-5{\cdot}18° \times 100}{220 \times 1} \times 100 = -235{\cdot}45°$ at 32° C.

For (13) $[\alpha]j = \frac{-2{\cdot}58° \times 200}{220 \times 1} \times 100 = -234{\cdot}54°$ at $31\frac{1}{2}°$ C.

Conclusions.

(*a.*) In the case of the sulphate, as has also been shown by Hesse and others, there is a greatly increased rotation power imparted to the alkaloid by its union with the acid. In the experiments presented the values are: for one gram of alkaloid to 50 cubic centimeters of solution $[\alpha]j = -154{\cdot}30°$ at 25° C. for the alkaloid: for one gram of alkaloid + sulphuric acid to 50 c. c. of solution in water $[\alpha]j = -258{\cdot}18°$ at 21° C., which applying the correction of ·650° for each degree Centigrade becomes $[\alpha]j = -255{\cdot}48°$ at 25° C. for the sulphate.

(*b.*) The aqueous solution of sulphate shows the same changes under the influence of temperature as the alcoholic solution of

the alkaloid, the difference being in the case of the alkaloid 1° C.$=-562°$ and in the case of the sulphate 1° C.$=-650°$.

(*c.*) In both the sulphate aqueous solution and the alcoholic alkaloid solution, there is the same diminished rotation under dilution, and this occurs chiefly in the first dilution as is shown in the following table:

	Alkaloid Solution.	Sulphate Solution.
1st dilution	$[\alpha]j = -137.50°$ at 35° C.	$[\alpha]j = -250.70°$ at 31½° C.
2d dilution	$[\alpha]j = -118.64°$ at 36° C.	$[\alpha]j = -235.45°$ at 32° C.
3d dilution	$[\alpha]j = -115.45°$ at 36° C.	$[\alpha]j = -234.54°$ at 31½° C.

In closing, I would direct attention to the results indicated in conclusion (*a*), wherein we find that the presence of sulphuric acid has changed the rotation power of a given weight of the alkaloid from $-154.30°$ to $-255.48°$; and I ask, is it not possible, nay, even probable, that the physiological action of the drug may undergo a similar or perhaps even greater increase? In past times it was the custom to administer quinine in the form of a sulphuric acid solution, and the results were certain and prompt even with minute doses. In recent times, on the contrary, the fancy of patients demands that quinine should be given in pill or some allied form; and though greatly increased doses are used, the practitioner finds it is less certain in its effect. The cause of the difference is doubtless the change in molecular arrangement that produces the marked difference in the action of the alkaloid and sulphate solutions on polarized light; and since the action of the sulphate solution is so much greater than that of the alkaloid solution it is evidently the proper form for the administration of Quinine as a Medicine.

College of the City of New York, Oct. 29, 1875.

ART. V.—*Description of some remains of an Extinct Species of Wolf and an Extinct Species of Deer from the Lead Region of the Upper Mississippi;* by J. A. ALLEN.

THE remains described in the present paper form part of the collection of mammalian fossils made many years since by Professor J. D. Whitney, from the lead-crevices and superficial strata of the lead region of Wisconsin, Iowa, and Illinois, being a part of those enumerated by the late Professor Jeffries Wyman in Whitney's Geological Report of the Lead Region of the Upper Mississippi (pp. 421–423), published in 1862.

The collection originally contained, besides those now described, other remains belonging to the genera *Mastodon*, *Megalonyx* and *Platygonus*, and an extinct species of *Bison*. In

addition to these I find an imperfect radius that seems not to differ at all from that of a young male *Cervus Canadensis*, and a part of another radius that does not differ appreciably from the corresponding part of a radius of *Antilocapra Americana.*

The remains of the fossil deer now described are those mentioned by Professor Wyman, namely a left metatarsus, a humerus and a radius, all more or less imperfect.* Professor Wyman described the humerus as "closely resembling that of the red deer, and of intermediate size between this and the humerus of the caribou." As these cervine remains evidently belonged to a species different from any hitherto described, either extinct or living, I propose for it the name *Cervus Whitneyi*, in honor of their discoverer, Professor J. D. Whitney.

The remains of *Canis* consist of a femur, two tibiæ and a humerus (the latter and one of the tibiæ in perfect condition), and may not have been those mentioned by Professor Wyman, although he enumerates parts corresponding to these; since it seems impossible that he could have described them as not differing in size from corresponding parts of the "gray wolf (*Canis occidentalis* Dekay,—*C. griseus* Sabine)," and as being not distinguishable from them; they in reality indicating a species of nearly twice the size of that animal. The rami and "fragment of a right upper jaw" mentioned by Professor Wyman as belonging to the same species are not now in the collection. This species seems to correspond in size quite nearly with the *Canis dirus* which Leidy described (first under the preoccupied name of *primævus*, and still later under the name of *Indianensis*)† from a portion of an upper jaw found with the remains of *Megalonyx*, *Tapirus*, *Equus* and *Cervus Virginianus* in the banks of the Ohio River near Evansville, Indiana, and also with the *Canis Haydeni* Leidy, described later from the Pliocene sands of the Niobrara River from a fragment of a right ramus. Since of the present species we have only a few of the bones of the limbs, it may be better to give it a provisional name than to refer it to either of the species already described, and await the reception of additional material to show their relationship. I accordingly propose for this species the name *Canis Mississippiensis*. As previously noticed, the remains associated with those now described nearly all belonged to extinct species, and to the fauna immediately preceding the

* Another specimen referred to under the head of *Cervus* by Professor Wyman as "an imperfect humerus of a much smaller animal than the preceding" belongs to the extinct peccary, (*Platygonus compressus*).

† *Canis primævus* LEIDY, Proc. Acad. Nat. Sci. Phila., vii, 200, 1854. Journ., Acad. Nat. Sci. Phila., iii, 167, pl. xvii, figs. 11, 12, 1856. (Name preoccupied).
Canis dirus LEIDY, Proc. Acad. Nat. Sci. Phila., 1858, 21. (Same specimen.)
Canis Indianensis LEIDY, Journ. Acad. Nat. Sci. Phila., vii, 368, 1867. (Same specimen.)

present. The bones, though light and somewhat soft, are still white and in an excellent state of preservation, and, though some are broken, have not suffered much abrasion. The humerus of the wolf shows the marks of the teeth of some small rodent.

CANIS MISSISSIPPIENSIS, sp. nov.

The remains of this species, consisting of a perfect right humerus, the distal two-thirds of a right femur, an entire left tibia and the greater portion of a right tibia, indicate a species of nearly if not quite twice the bulk of the existing large wolf of the northern hemisphere (*Canis lupus*), and which had a stature fully one-fifth greater, the difference between them being nearly as great as that between *Canis lupus* and *Canis latrans*. The bones do not differ appreciably in respect to form from those of *Canis lupus*. Their measurements (given in millimeters), in comparison with those of the corresponding bones of a specimen of *Canis lupus* (number 268 of the Museum of Comparative Zoology) from Kansas are as follows:—

Comparative Measurements of Bones of *Canis Mississippiensis* and *Canis lupus*.

	C. Mississippiensis.	C. lupus.
Humerus.—Total length,	223	176
Greatest diameter of proximal end,	55	44
Antero-posterior diameter of head,	41	34
Greatest transverse diameter of distal end,	46	37
Greatest antero-posterior diameter of inner condyle,	36	28
Least circumference of shaft,	62	50
Femur.—Total length,	---	193
Transverse diameter of axis and great trochanter,	---	45
Transverse diameter of condyles,	43	35
Antero-posterior diameter of condyles (inner side),	53	39
Least circumference,	56	44
Length of corresponding parts (distal two-thirds),	155	123
Tibia.—Total length,	244	200
Transverse diameter of head,	47	38
Antero-posterior diameter at most elevated point of the tuberosity,	43	35
Transverse diameter of distal end,	31	24
Least circumference of shaft,	52	43

CERVUS WHITNEYI, sp. nov.

The remains of this species, consisting of a left humerus, entire except lacking the proximal epiphysis, a left radius, also

lacking the distal end, and a right metatarsal, which has also lost the distal termination, indicate a species of about the same proportions as *Cervus Virginianus*, but much larger, considerably exceeding in size *Cervus macrotis*. The measurements given below indicate the fossil species to have been at least one-seventh larger than *C. macrotis*, and apparently more than one-fifth larger than *C. Virginianus*. A comparison of the bones themselves give a stronger impression of the greatly larger size of the fossil species than do the tabulated measurements. In respect to form, the humeri of the three species do not materially differ, although the condyles in *C. macrotis* have a rather greater relative breadth than in either of the other species. The radius also differs but little in form in the three, but in the fossil species the ulna (it has now been broken away and is lost) was solidly anchylosed with the radius nearly throughout its length, being free only near its distal extremity, whereas in *C. macrotis* it is anchylosed for only its middle portion, being not only free proximally as well as distally, but for quite a space near the proximal end does not even touch the radius, there being an interval of fully two millimeters between them. In *C. Virginianus* the radius and ulna are nearly as fully anchylosed as in the fossil species. The metatarsal bone is similar in form to that of *C. macrotis*, except that it is relatively more compressed laterally in its distal portion, and seems to have been (the distal end is lacking) relatively narrower at its lower articulation. In this respect it corresponds more nearly with the distal portion of the metatarsus of *C. Virginianus*, which is much rounder and relatively more slender than that of *C. macrotis*. The metatarsal of the fossil species differs from that of *C. Virginianus*, however, in having the groove of the posterior surface continued much further distally than in that species. In the following table of comparative measurements the specimens taken are middle-aged males, the *Cervus macrotis* (No. 1781 of the Mus. Comp. Zool.), being from the Medicine Bow Mountains, Wyoming Territory, and the *C. Virginianus* (No. 1733 of the Mus. Comp. Zool.) from Maine.

Comparative Measurements of Bones of *Cervus Whitneyi*, *Cervus macrotis*, and *Cervus Virginianus*.

	C. Whitneyi.	C. macrotis.	C. Virginianus.
Humerus.—Total length,	---	227	220
Length from most prox. part of head to most dist. part of inner condyle,	---	203	200
Breadth of condylar surface,	48	42	38
Antero-posterior breadth of inner condyle,	51	42	42
Least circumference of shaft,	85	76	73

	C. Whitneyi.	C. macrotia.	C. Virginianus.
Radius.—Total length,	---	242	230
Transverse breadth of proximal end,	---	39	37
Transverse breadth of distal end,	41	38	36
Least transverse diameter of shaft,	29	25	24
Least circumference,	80	68	65
Metatarsus.—Total length,	---	273	255
Transverse breadth of proximal end,	33	29	28
Antero-posterior breadth of proximal end,	36	32	30
Transverse breadth of distal end,	---	35	33
Least transverse diameter of shaft,	22	21	18
Least circumference of shaft,	67	66	58
Length of corresponding portions (proximal five-sixths),	273	232	220

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Action of Nitric Acid on Silver and Copper, alone and in presence of Nitrates.*—Acworth has examined at length, in the laboratory of Dr. Frankland, the gases which are evolved by the action of nitric acid on metals, both with and without the presence of nitrates in the solution. The following are his conclusions: (1) cold dilute nitric acid acting on copper evolves nearly pure nitrogen dioxide; (2) in presence of a strong solution of cupric nitrate, this same action gives rise to nearly pure nitrogen monoxide; (3) potassium nitrate has no effect; (4) ammonium nitrate causes the evolution of nitrogen and nitrogen monoxide, mixed with some dioxide; (5) nitric acid, acting on zinc or iron in presence of ammonium nitrate, evolves nearly pure nitrogen; (6) mercury under the same circumstances acts similarly; (7) on silver, the gaseous products are nitrogen and nitrogen dioxide, with scarcely a trace of the monoxide; (8) in presence of ammonium nitrate, silver produces nitrogen chiefly, mixed with a little nitrogen dioxide.—*J. Chem. Soc.*, II, xiii, 828, September, 1875. G. F. B.

2. *On the Condensability of the Gaseous Products of the distillation of Carbonaceous Shales.*—Distillation of carbonaceous shales at a low temperature, is extensively resorted to, as is well-known, for the production of liquid hydro-carbons for illuminating purposes. The large amount of gas simultaneously produced, and its high illuminating power, suggested to Coleman a series of experiments upon the condensability of these gaseous products. For this purpose a compression-pump was provided, by which the gas was condensed into an iron tube. This tube was

slightly inclined, and at about three-fourths of its length, a reservoir was placed. Beyond this the gas passed through copper tubes which were immersed in a freezing mixture. Upon the main tube was a safety valve which allowed the pressure to be regulated at pleasure; this was maintained at about 140 pounds to the square inch. In the first experiment, 538 liters of gas were passed through the apparatus, in the second 467 liters, and in the third 1274 liters. In both reservoirs, 84 c. c. of liquid was obtained in the first experiment, 77 c. c. in the second, and 195 c. c. in the third. Of the 77 c. c., 54 c. c. of sp. gr. ·690 condensed in the first reservoir (i. e., by pressure alone without cold) and 23 c. c. in the second, of sp. gr. ·650. Of the 195 c. c., 114 c. c. of sp. gr. ·691 condensed at + 16°, and 81 c. c., of sp. gr. ·658, condensed at —18°. As a mean therefore each liter of gas yielded about ·158 c. c. of liquid of sp. gr. ·680; which is equivalent to one gallon for each 1000 feet of gas. After this treatment the gas was found to have lost its illuminating power, giving no more light when burned from a bat wing jet than does a Bunsen burner. From this and other facts, the author concluded that ethylene is absent from shale gas. Common coal gas when subjected to this treatment gave no appreciable quantity of liquid. The shale products, by weight, therefore, which are obtained on distillation, are:—non-luminous combustible gas 20·9 per cent; volatile liquids, sp. gr. ·680 dissolved as vapors in the gas 4·9 per cent; commercial paraffins, sp. gr. ·700–·800, 52·3 per cent; tarry acid or basic bodies 21·9 per cent. The author proposes a method for commercially preparing these light oils from the gas.—*J. Chem. Soc.*, II, xiii, 856, Sept., 1875. G. F. B.

3. *On the Medico-legal determination of Arsenic.*—Having occasion to revise, for purposes of physiological investigation, the methods ordinarily employed for the detection of arsenic in the tissues,* GAUTIER ascertained that they were seriously deficient in quantitative exactness. He thereupon devised an improved method of separating the arsenic from the organic matter, based upon those of Orfila and Filhol, and a modification of the method of Marsh, by which the arsenic is obtained in a weighable form. The former is as follows:—100 grams of the finely divided animal matter is placed in a porcelain capsule with 30 grams pure nitric acid, and moderately heated. At first the mass liquefies, then it thickens and becomes orange-colored. The capsule is taken from the fire and 5 grams pure sulphuric acid are added. Heat is again applied till white fumes appear. Then 10 or 12 grams of nitric acid is allowed to flow drop by drop on the residue, and it is heated to carbonization. An easily pulverizable mass is thus obtained, which is exhausted with boiling water, filtered, the filtrate reduced with a few drops of hydro-sodium sulphite, and precipitated as usual, by a current of hydrogen sulphide. The arsenous sulphide, transformed into arsenic oxide by nitric acid, is ready for the Marsh apparatus. This consists of a

* See this Journal for December, 1875, page 474.

flask of 180 to 200 c. c. capacity, having two tubulures, and placed in a vessel of cold water. In it are placed 25 grams of pure zinc, on which is poured sulphuric acid diluted with five parts of water. The disengaged gas passes through cotton and then through a tared glass tube heated to redness by charcoal for a length of 20 to 25 cm. The air being expelled, the arsenic, mixed with more dilute sulphuric acid is poured into the apparatus in small portions, an hour being required for the introduction of 5 milligrams of arsenous oxide. The action is kept up for two hours longer, by which time all the arsenic has been carried over. Copper sulphate hinders, platinum chloride facilitates the separation of the arsenic from the solution. After the evolution of gas ceases, the tube containing the annulus of arsenic is weighed again and the amount of arsenic determined. The results are very accurate. In two experiments, in which 5 milligrams arsenous oxide were mixed with 100 grams muscular tissue, the rings weighed 3·72 and 3·67 milligrams respectively; the theoretical quantity being 3·79 milligrams. In a third, 2½ milligrams arsenous oxide were mixed with 100 grams blood; the annulus weighed 1·78 milligrams, the calculated weight being 1·88 milligrams. In 2·1 grams of the brain of a rabbit, fed for 15 days with doses of arsenous oxide gradually increasing from 5 to 50 milligrams, the arsenic recovered was sufficient to give a brilliant ring nearly a centimeter long. A vigorous dog was fed with gradually increasing doses of arsenous oxide, from 4 to 80 milligrams, for a month. 100 grams of the liver yielded 5·3 milligrams, and 100 grams of muscle yielded 0·27 milligram of metallic arsenic.—*Bull. Soc. Ch.*, II, xxiv, 250, Oct., 1875. G. F. B.

4. *Formation of Nitrites by Bacteria.*—The presence of nitrites in spring waters, which has usually been ascribed to the oxidation of ammonia therein, is now stated by MEUSEL to be produced by the reduction of nitrates by the agency of bacteria. In proof of this, he shows: that such water which contained bacteria and nitrates, but neither ammonia nor nitrites, gave, after standing four days, the reactions of nitrous acid; that antiseptics such as salicylic acid, phenol, benzoic acid, alum, and much salt even, prevent or hinder the production of nitrites; that aqueduct-water containing pure nitrates, which alone does not show the production of nitrites even in presence of bacteria, has this change effected upon the addition of glucose, gum, dextrin, cellulose, starch, etc., in the course of from 2 to 14 days; that freshly distilled water, boiled with glucose and niter, shows no nitrites even after standing for weeks, because bacteria are absent: and that putrefying albuminates reduce nitrates to nitrites. The decomposition of cellulose by bacteria in presence of nitrates proves that niter is not only direct food for plants, but that it also performs by its oxygen an important function in the soil. The author believes that these facts have important bearings in agriculture and in medicine.—*Ber. Berl. Chem. Ges.*, viii, 1214, Oct., 1875.

G. F. B.

5. *On the supposed new Hydrocarbon, C_3H_2.*—A short time ago PINNER described * a new hydrocarbon obtained by the action of sodium upon dichlorallylene, to which he assigned the formula C_3H_2. Further investigation has shown him that the formula is more probably C_3H_4 and that the body in question is either allylene itself or an isomer of it. Assuming dichlorallylene to be $C_3H_2Cl_2$, the action of a molecule of sodium upon one molecule of it would be $C_3H_2Cl_2+Na_2=(NaCl)_2+C_3H_2$; but if C_3H_4 is produced, two stages of the reaction are required; $C_3H_2Cl_2+(Na)_4=(NaCl)_2+C_3H_2Na_2$ and $C_3H_2Na_2+(H_2O)_2=(NaOH)_2+C_3H_4$. In the former case the resulting aqueous solution must contain chlorine and sodium in atomic proportions; in the latter, the sodium is double the chlorine. While more alkali than chlorine was always found, it was far from being twice the quantity. To solve the problem, therefore, the author analyzed carefully the tribromide. While C_3HBr_3 requires 13·0 per cent C and 0·4 per cent H, $C_3H_3Br_3$ requires 12·9 per cent C and 1·1 per cent H. In two analyses the carbon was 13·02 and 12·91, and the hydrogen 1·15 and 1·17 per cent. These results, which contradict the former ones, led the author to examine more carefully the composition of dichlorallylene. He finds that instead of its being $C_3H_2Cl_2$ as assumed, it is really $C_3H_4Cl_2$, having 3·6 per cent hydrogen instead of 1·83 which the first formula requires. This fact harmonizes both the above observations and settles the new hydrocarbon as C_3H_4. Hence the product of the action of chlorine upon aldehyde is not crotonyl chloral, but butyl chloral; though from it, however, crotonic acid has been obtained by Sarnow. This problem, Pinner is now occupied in solving.—*Ber. Berl. Chem. Ges.*, viii, 1282, Nov., 1875. G. F. B.

6. *On Aromatic Compounds containing Arsenic.*—MICHAELIS has published a preliminary note upon phenyl-arsenous chloride, $AsCl_2C_6H_5$, which he obtained by the action of arsenous chloride upon mercury-diphenyl, in a sealed tube at 170°. The reaction is given as follows:

$$Hg(C_6H_5)_2+(AsCl_3)_2=HgCl_2+(AsCl_2C_6H_5)_2.$$

It is a heavy, colorless, strongly refractive liquid, slowly decomposed by water. Investigations upon this and other analogous metallic derivatives are in progress.—*Ber. Berl. Chem. Ges.*, viii, 1316, Nov., 1875. G. F. B.

7. *On Diacetone-alcohol.*—HEINTZ, who has been recently investigating the amines derived from acetone by the action of ammonia, has examined diacetonamine, to see whether the reaction with its nitrite would result, as is general with other amines, in the production of an alcohol; the nitrogen of both being eliminated as gas, and hydroxyl taking the place of amidogen. Diacetonamine oxalate was dissolved in three times its weight of hot water, and cooled to 5°. To the liquid kept constantly stirred, potassium nitrite was gradually added, in amount equal to

* Abstract in this Journal, III, x, 293, October, 1875.

nearly twice the weight of the oxalate. After standing several days, the temperature being allowed slowly to reach that of the atmosphere, the liquid was distilled, whereby some mesityl oxide passed over. The residue, freed from an oily layer by a separating funnel, was neutralized with potassium carbonate and agitated with ether. The etherial solution, dried by calcium chloride, left on distilling off the ether, a liquid boiling between 163·5° and 164·5°, having the formula, $C_6H_{12}O_2$. Its vapor density was 4·19. This is diacetone-alcohol, and it has the rational formula

$$CH_3 . CO . CH_2—\overset{CH_3}{\underset{CH_3}{C}}—OH.$$

—*Liebig's Annalen*, clxxviii, 342, Oct., 1875. G. F. B.

8. *A new relation between Electricity and Light.*—Mr. John Kerr has succeeded in showing that dielectrified media are birefringent. Two holes were drilled in a block of plate glass so as to leave a space of only about a tenth of an inch between their ends. Copper wires covered with rubber and shellac were inserted into these holes, and the current from an induction coil capable of giving a spark of 20 to 25 cms. passed through them. A second passage is opened to the current of variable length through the air, so that when the spark passes the glass is subjected to an electric strain. The light of a lamp is passed through a Nicol prism, then through the glass, and finally through a second Nicol at right angles to the first. Since every plate of glass exerts a depolarizing action a certain amount of light is transmitted. This is cut off by interposing a second piece of the same plate of glass and slightly turning one of the Nicols. If the plane of polarization is inclined 45° to the line along which the electric action is exerted through the glass on closing the primary circuit, light will be visible in about two seconds. It brightens continuously for nearly half a minute, and if the current is broken, will gradually fade away. The light thus restored cannot be extinguished by any rotation of the analyzer. If the plane of polarization is parallel or perpendicular to the lines of electric force no action is obtained. There is as great an effect with a rapid succession of contrary electrizations as with a continued electrization in one direction.

A small square of glass held edgewise in a vice was then introduced in the path of the beam and compressed feebly horizontally. A second plate like a microscope slide was also inserted and bent by the hands until the light introduced by the depolarization of the first plate was extinguished. From this arrangement of the apparatus, it appears that the dielectrization of the plate glass is equivalent optically to a compression of the glass along the lines of electric force. Dielectrified glass acts upon transmitted light as a negative uniaxial crystal with its axis parallel to the lines of force.

Half a dozen other solids were tried, but only two, resin and quartz, gave results worth mentioning. The great difficulty was to get a sufficiently strong superficial insulation, the masses being

too small. A plate of resin was employed of nearly the same size as the glass. Small squares of thin plate glass were placed in optical contact with its two faces and parallel to each other. It gave evidence of irregular strain near the terminals, separated the red and blue rays by a small angle, and was imperfectly transparent. But its chief defect was that it allowed a spark discharge over its surface a length of 7 inches before the distance of the spark terminals much exceeds 2·5 inches. With all these deficiencies, however, it gave a regular and definite effect, and the action was contrary to that of glass.

A plate of quartz cut perpendicular to the axis, 3 mms. thick and 20 long, was employed with a result similar to that of glass.—*Phil. Mag.*, l, 337. E. C. P.

9. *Waves on Mercury.*—M. C. DECHARME states that by blowing through a tube touching the surface of mercury, we may produce a sound and circular waves forming a symmetrical network upon the liquid. The smaller the interior diameter of the tube, the higher and weaker is the sound and the shorter the waves. As long as the diameter is less than about half a millimeter, the sound resembles the buzzing of an insect. When the diameter amounts to ·7 or ·8 mms. the sound assumes a clear and distinct musical character. With larger tubes the note becomes loud. There is a great tendency of the sounds to pass to their harmonics, with slight changes of the pressure of the air or of the length of the immersed portion of the tube, especially when the latter has a diameter of 2 to 5 mms. For this reason it is difficult to obtain single sounds, but they are almost always high and unstable harmonies. The best results are attained with tubes 0·8 to 5 mms. in diameter, held vertically so as just to touch the surface, and cut off perpendicular to their axes. The tube is then connected with a large rubber vessel full of air and compressed by a weight which should be greater the smaller the tube.

In general the sounds thus produced depend, as regards their height, quality and intensity, on the diameter, length and nature of the tube, the thickness of its edges, the form of the edges of the orifice, and on the temperature, pressure and nature of the gas; finally and above all, on the capacity of the reservoir of air, or rather on the harmonic ratio of its volume to that of the sounding tube and of the connecting tube. This last condition is so essential that a tube giving good results with one reservoir will not work satisfactorily with another. An important application of this device is to the production and projection of interference waves in an elliptical vessel. The nodes and loops are in this case clearly marked, fixed and symmetrical. The concord of the third, fifth and octave may be similarly projected on a screen with great clearness by employing two sounding tubes.—*Journ. de Phys.*, iv, 207. E. C. P.

10. *Spectrum of the light of the blue Grotto of Capri.*—Dr. H. W. VOGEL, on a recent visit to Capri, tested the light of the blue grotto with a spectroscope. As the entrance is only about four

feet in breadth and height, a large part of the light which enters passes through the water. The spectroscope shows that the red is wholly absorbed by the water, and the yellow is so far enfeebled that the D line was scarcely visible. The green, blue and indigo on the other hand shone out brightly, with the F and *b* lines united in a well-marked absorption line.—*Pogg. Ann.*, clvi, 326.
E. C. P.

11. *Action of Magnetism on an Electric Spark.*—M. H. Becquerel has shown that the action of a powerful electromagnet when its current is broken between its poles, is purely mechanical. The spark in this case is accompanied by an explosion, and takes the form of a small flame, which seems to be projected by the action of the magnet as it would be by a current of air. The same effects may be produced by a bellows or even by the mouth. A little explosion is produced, increasing in strength with the force of the air current. It is generally admitted that the sound accompanying the induction spark is due to a sudden expansion of the air and of the volatilized portions of the electrode, followed by a sudden return of the particles to their former position. According to this view the shorter the time of discharge the louder should be the noise.

The substitution of the purely mechanical action of a current of air seems to show that under the influence of the air current as with the magnet, the effect is due to a sudden rupture of the chain of molecules which transmit the electric current of only short duration, forming the induction current. The time of discharge being thus notably diminished the sound accompanying it assumes a remarkable intensity. The idea of making an air-current act in this way is due to M. de Moncel, who has employed it to separate the spark from the aureole.—*Journ. de Phys.*, iv, 206.
E. C. P.

12. *Interference Fringes.*—M. Nodot suggests the substitution of rhombs of Iceland spar for Nicol's prisms in forming the interference fringes of Fizeau and Foucault. The sunlight is admitted through a narrow slit, and focussed on the slit of the spectroscope by a lens. Two rhombs of spar are then interposed, and between them is placed a plate of quartz, cut parallel to the axis, and inclined 45° to the planes of polarization of the spars. Three images of the rhomb are thus formed, the central one of double the brilliancy of the others, since it is formed by the superposition of two images. Allowing each image in turn to fall on the slit of the spectroscope, it will be seen that fringes are present in all three, those of the two outer images being complimentary to the fringes of the central image. Evidently the brilliancy of the effect will be double that usually attained, since a Nicol's prism necessarily cuts off at least half the light.

The experiment may be varied by forming the three images one above the other, and allowing all to fall on the slit of the spectroscope, when a spectrum is formed in which the upper and lower parts are fainter than the central portion, and the fringes of the

former are complimentary to those of the latter. In other words the bright portions of one set correspond to the dark parts of the other.—*Journ. de Phys.*, iv, 209. E. C. P.

13. *The Wind Theory of Oceanic Circulation. Objections examined;* by JAMES CROLL, of H. M. Geological Survey of Scotland. (From the Philosophical Magazine for October, 1875).*—*The fundamental arguments of the advocates of the gravitation theory.*—1. The gravitation theorists base their argument on two principal assumptions which cannot be conceded. First, they maintain that the existence of polar water in the depths of the ocean is consistent with their theory only; and, secondly, they assume as a necessary condition of the wind theory that the understratum of the ocean should consist of warm water. It is a well recognized fact that the ocean beyond the reach of sun heat is occupied with water of a polar temperature; and they therefore point triumphantly to the fact as at once a proof of their position and a conclusive argument against the wind theory. But, on the other side, it will not be difficult to show that the existence of cold water throughout the ocean depths is as much a necessary result of the wind theory as of the gravitation theory, and that there is no relation whatever between the wind theory and warm water in the depths of the sea.

It is supposed that the return *under-currents* from the polar regions are by far too insignificant to be able to maintain at a polar temperature the great depths of the ocean.

Let us examine this objection. It is freely admitted, nay even strenuously maintained by the advocates of the gravitation theory themselves, that the heating-power of the sun does not extend to any great depth below the surface of the ocean; consequently there is nothing whatever to heat this mass of water underneath except the heat coming through the earth's crust; but the amount of heat derived from this source is so trifling that an under-current from the Arctic regions of no great magnitude would be sufficient to keep the mass at an ice-cold temperature.

On a former occasion† I showed that, taking the rate at which internal heat passes through the earth's surface to be that assigned by Sir William Thomson, the total amount received per annum by the North Atlantic, between the equator and tropic of Cancer, including the Caribbean Sea, is equal to only $\frac{1}{814}$ of that conveyed by the Gulf-stream, on the supposition that each pound of water carries 19,300 foot-pounds of heat,—and that consequently an under-current from the polar regions of not more than $\frac{1}{55}$ the volume of the Gulf-stream would suffice to keep the entire mass of water of that area within 1° of what it would be were no heat derived from the crust of the earth, and an under-current of less than $\frac{1}{17}$ that of the Gulf-stream coming from the polar regions would keep the entire North Atlantic from the equator to the arctic circle filled with ice-cold water. A polar under-current half

* Received for this Journal from the author.

† Philosophical Magazine, June, 1874; "Nature," vol. x, p. 52.

the size of the Gulf-stream would be sufficient to keep the entire water of the globe (below the stratum heated by the sun's rays) at an ice-cold temperature. Internal heat would not be sufficient under such circumstances to maintain the mass 1° Fahr. above the temperature it possessed when it left the polar regions.

In short, whatever theory we adopt regarding oceanic circulation, it follows equally as a necessary consequence that the entire mass of the ocean below the stratum heated by the sun's rays must consist of cold water. For if cold water be continually coming from the polar regions, either in the form of under-currents, or in the form of a general underflow as Dr. Carpenter supposes, the entire under portion of the ocean must ultimately become occupied by cold water; for there is no source from which this influx of water can derive heat, save from the earth's crust, which amount is so trifling as to produce no sensible effect.

It is therefore evident that the great mass of cold water occupying the depths of the ocean cannot be urged as an objection to the wind theory.

2. But it is asserted that the impulse of the wind on the surface of the ocean cannot produce and maintain deep under-currents. This is an objection which has been urged by some eminent physicists; but it is based upon a misapprehension of the manner in which, according to the wind theory, under-currents are produced.

It is true, as the objectors maintain, that a wind simply impelling the water forward will not necessarily produce an under-current, since compensation will more readily take place by return surface-currents, as in this case the path of least resistance will generally be at the surface. But when the general surface of one half of an ocean basin is being constantly impelled forward by prevailing winds in a contrary direction to that in which it is being impelled in the other half, compensation cannot possibly take place by means of return surface-currents. For a full discussion of this point I must refer the reader to my work, "Climate and Time," Chap. XIII.

It is, however, needless to advance arguments *à priori* against the possibiliy of such under-currents; for we have actually several well-known examples of such currents, the particulars of which will also be found in the work to which I refer.

3. But supposing it could be shown that the winds cannot directly produce under-currents, it can nevertheless be demonstrated that they can do so indirectly. A vertical circulation filling the deep recesses of the ocean under the equator with polar-cold water, follows as readily and truly from the wind theory as it does from the gravitation theory. It has been shown that the general tendency of the system of the winds is to impel the surface-water of the equatorial regions into the temperate and polar regions as rapidly as it is heated. But such a transference of surface-water must tend to destroy static equilibrium by making the equatorial too light and the temperate and polar columns too heavy, as truly as though the transference had taken place by

means of difference of temperature. The effect must be to produce a constant ascent of the equatorial column and an *inflow* of cold water below equal to the *outflow* above. In short, the wind must produce a system of circulation precisely the same as that supposed to take place by difference of temperature.

By both theories the cause of the vertical motion is the transference of water from the top of the one column to the top of the other. This vertical motion is therefore as much a necessary consequence of the wind theory as it is of the gravitation theory.

II. Geology and Mineralogy.

1. *On the Gravel and Cobble-stone deposits of Virginia and the Middle States;* by Wm. B. Rogers. (Proc. Boston Soc. Nat. Hist., vol. xviii, 1875, 101.—The deposits here described as occurring in the great river valleys and on the adjoining slopes, at Richmond, Va., Washington, D. C., and elsewhere, consist chiefly of layers of water-worn gravel and stones, with ferruginous sands and clays. In most localities the larger pebbles are found in the upper part of the deposit; but in others, as at Alexandria and Richmond, the cobble-stone deposit is overlaid by bedded sands and gravel. Casts of Scolithus occur in some of the pebbles collected at Washington and Richmond. The deposit at Washington covers the entire plain on which the city is built; it averages 75 feet in height above mean tide, but rises on the north to about 100 feet. Thence it spreads over the slopes, covering the grounds of Columbian College, and the higher hill of the Soldiers' Home, over 200 feet above sea level. In the vicinity of the Capitol the stones are often a foot in diameter, and near Georgetown in a recent excavation some are much larger. The facts point to transportation along the valleys, but by streams of much greater width than those now there. The distance transported may be learned from the fact that the nearest Potsdam or Scolithus sandstone to Richmond is 80 miles, and along James River 160 miles; and that from Washington to the western side of the Blue Ridge is 40 miles, and along the Potomac 50 to 60 miles. Prof. Rogers remarks on the origin of these deposits as follows:

"Speculating on the causes by which these deposits have been formed, it may, on the one hand, be imagined that during the Glacial period the icy covering of the north and west prolonged itself in the valleys of the great rivers, as far south as the James, and even the Roanoke River, bringing down to the belt of land now marking the limit of tide water debris from the Appalachian rocks, mingled with materials derived from the intervening region, and that the grinding and sorting action of the waters subsequently obliterated glacial marking, and gave to the whole deposit the distribution and stratification which it now presents; or, on the other hand, it may be conceived that the transporting force of the rivers themselves, swollen and rapid as they must have been in the closing ages of the Glacial period, brought about the same results. But even in this case, it is

highly probable that glacial action had much to do with the original accumulation of the rocky debris on the flanks of the Blue Ridge, and in the Appalachian valleys beyond."

Prof. Rogers further observes that there is a siliceous and argillaceous formation in Virginia, easily confounded with the finer drift beds, which underlies the Tertiary, and is placed by him at the base of the Cretaceous formation or top of the Jurassic; that sections are exposed in a deep railroad cut between Washington and Baltimore, and on the way to Wilmington; that it is seen beneath the Cretaceous green-sand in Maryland, Delaware, and New Jersey, and near Baltimore was found by Prof. Tyson to contain stumps of Cycads. When the Cretaceous and Tertiary are absent these beds are easily confounded with the stratified drift. Its contact with the superficial deposits was well presented in April, 1875, near Washington, at a cut at the extremity of 16th street, at the base of the Columbian College Hill, and on 14th street where it ascends the same hill.

2. *Report of the Geological Survey of North Carolina*, Volume I. *Physical Geography, Resumé, Economical Geology;* by W. C. KERR. By authority of the General Assembly. 326, 120 pp. 8vo. Raleigh. 1875.—The Geological survey of North Carolina under Prof. Kerr was commenced in 1866. The report now issued was presented to the Legislature in 1870, but not then ordered for publication; and now it appears in 1875 "under a permissive resolution, out of the working fund of the Survey." A second volume, the preface states, will go to press during the year.

The report commences with an introductory chapter on the Physical Geography of the State. In the course of it the fact is brought out that on the *south* side of the rivers in eastern North Carolina there are usually bluffs and high banks, and on the *north*, swamps and low flats; and that this is a feature also of eastern South Carolina. Further, the Miocene shell-beds were found only on the *south* side of these large rivers. "The cause," according to the author, "is doubtless the rotation of the earth co-acting with the river current;" and he cites the law of motion, wrought out with mathematical demonstrations by Prof. Ferrel, that, "in whatever direction a body moves on the surface of the earth, there is a force arising from the earth's rotation which deflects it to the right in the Northern hemisphere, but to the left in the Southern." The chapter treats of the topographical features and climate of the State and contains a long table of altitudes.

On its Geology the author gives only the general outlines. The series of rocks includes those of the Archæan, which are made to cover (1) a large area running northeastward across the State immediately west of its center and extending westward to include the Blue Ridge; also (2) an area in central North Carolina running north-northeast from Raleigh, and some small areas in that vicinity, one of them to the south on the Cape Fear River; and (3) an area west of the Blue Ridge. The first consists largely of syenyte and related hornblendic rocks, which rarely con-

tain mica and are not schistose; the *second*, of light and gray fine-grained gneisses with some ledges of coarse syenyte and masses of titaniferous magnetite or hematite; one bed of hematite on the Cape Fear River being 40 feet thick; the third of gneiss, hornblendic and mica schists, with some syenyte and coarse granite, and a belt of chrysolyte ledges. The coarse granite of the third area affords much mica in large plates, some 20 inches across; and the mining operations for the mica date back to the mound-builders, the granite veins being "honeycombed with the ancient tunnels and shafts, which were located and excavated with more skill and success than the modern workers have yet attained."

No Silurian rocks are recognized, unless on the extreme western border, within what the map colors as Archæan, where, according to Prof. Bradley, the Lower Silurian exists as a continuation of rocks of that era in Tennessee.

The remaining formations described are the Triassic, the Cretaceous, and the Tertiary. The two Triassic areas, one on Deep River and the other on Dan River, at a distance 75 to 100 miles from one another, have the rocks dipping in opposite directions, those of Deep River, or the more eastern area, dipping southeastward about 15° to 35°, and those of the other northwestward 35°. Prof. Kerr makes the supposition—improbable as it appears to the writer—that the two are the margins of a single anticlinal that once spanned the broad interval between them. The Connecticut River Triassic has in general a similar southeastward dip; but there is no where the opposite side of the anticlinal unless we look to the New Jersey area for it, which is quite too far south to answer.

A large part of the volume is occupied with a chapter on Economical Products of North Carolina. It embraces a large amount of information on soils; marls and fertilizers; peat and muck; ores and mines (among which those of iron are very extensive, and those of gold and copper, also, have been profitably worked); coal (Triassic); graphite, and kaolin; fire-clay, pyrophyllite, corundum, mica, and mineral waters.

The coal field of Deep River has an area of about 300 square miles. Dr. Genth obtained in an analysis of two samples, fixed carbon 63·28, 70·48, volatile matter 25·74, 21·90, ash 10·14, 6·46, moisture 0·84, 1·16=100. It contained sulphur 1·35, 1·02. The Dan River coal afforded the same chemist 75·96 and 76·56 p. c. of fixed carbon, 11·44, 13·56 of ash, the volatile matter in each about 12 per cent.

The report contains also a well-colored geological map of North Carolina and several plates of fossils.

3. *Second Geological Survey of Pennsylvania.*—The following Reports for 1874 have recently been published by the State Board of Commissioners at Harrisburg.

Report of Progress on the Brown Hematite (Limonite) Ore Ranges of Lehigh County, with a description of the mines lying between Emaus, Alburtis and Fogelsville; by FREDERICK PRIME, Jr., Assist. Geol. 74 pp. 8vo, with cuts and maps.

Report of Progress in the Venango Co. District; by JOHN F. CARLL. *Observations on the Geology around Warren;* by F. A. RANDALL. *Note on the Comparative Geology of Northwestern Ohio and Pennsylvania and Western New York;* by J. P. LESLEY. 128 pp. 8vo, with wood-cuts and maps.

Report of Progress in the Laboratory of the Survey, at Harrisburg; by ANDREW S. M'CREATH. 106 pp. 8vo.

Prof. Prime gives in his report a brief account of the topography and geology of the district under examination, and of the rocks with which the limonite ores are associated. These rocks are stated to be of the magnesian limestone series—that is, Lower Silurian beds of the age of the Calciferous sandrock, and the Chazy, Birdseye and Black River limestones. Mr. Prime says: "The great mass of this formation is dolomite; but there occur one and possibly more beds of hydro-mica (or damourite) slate intercalated in it. The limonite ore always accompanies the hydro-mica slate, and with it there is often clay from the decomposition of the slate. The following are three out of five analyses of this slate from Lehigh Co.:

	$\ddot{\mathrm{Si}}$	$\bar{\mathrm{Al}}$	$\bar{\mathrm{Fe}}$	$\dot{\mathrm{Mg}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Na}}$	$\dot{\mathrm{K}}$	$\dot{\mathrm{H}}$	
1. Fogelsville	49·92	34·06	0·91	1·77	0·11	0·74	6·94	6·52	= 100·97
2. Hensingerville	45·40	24·69	5·06	13·56	tr.	0·27	5·85	4·80	= 99·63
3. Near Allentown	59·30	30·30		trace	tr.	1·51	6·24	4·70	= 102·05

From the amount of the potash in the first analysis (by Dr. Genth), Mr. Prime calculates the amount of damourite present (with free silica, etc.) to be 55·40 p. c.; in the second (by Mr. S. Castle), 49·70 p. c.; in the third (by Mr. P. G. Salom), 53·02 p. c. This hydro-mica slate, with often associated limonite beds (as a result of alteration), extends, as Mr. Prime observes, from Vermont to Alabama, showing thus a long range of Lower Silurian rocks in the eastern mountain region of North America.*

The report describes further the mines and ores, and gives many analyses. It is followed by a note from the State Geologist, making some explanations with regard to the equivalency of the Pennsylvania formations, and remarking on some topographical changes the country has undergone. Mr. Lesley goes outside of his field in his closing remarks, and states—what is sustained as yet by no adequate stratigraphical evidence—that the "Green Mountain system of Vermont" and "the White Mountain system of New Hampshire," are, like "the Laurentian Mountains of Canada," older than the Potsdam; and that the Green Mountain system, one of these "three great mountain systems of the north," is Huronian. The observations by Mr. Prime in Pennsylvania, above-mentioned, and the parallel facts in the Green Mountain system to which he draws attention, all point as regards the Green Mountains in the opposite direction. The writer has studied stratigraphically the Green Mountain region from Con-

* The first determination of the fact that the so-called talcose slates are mostly hydro-mica slates is accredited to Prof. Dana. The latter gives the credit to others in this Journal (III, iv, 366, 1872), where he named the rock *hydro-mica slate*.

necticut to Vermont, and has found that the hydro-mica and chloritic hydro-mica slates associated with the limonite beds of Berkshire are of the same formation with the hydro-mica, chloritic, and micaceous slates of Graylock and the Taconic range; and with the hydro-mica slates of the ridge lying northeast of Rutland in Vermont, and of others west and north of Rutland; and with the staurolitic schists of the limonite region of Salisbury, Connecticut. Since the limestones associated with the slates of West Rutland abound in distinct Lower Silurian fossils, referred to the Chazy by Billings,* part of the Green Mountain slates and schists are unquestionably Lower Silurian. What is the age of the rest is not yet positively known.

Mr. Carll's report contains the results of his observations in the oil district of Venango County—giving in detail the geological and topographical distribution of the oil, and its distribution also in depth.

Mr. Lesley's notes on the comparative geology of the adjoining parts of the States of Ohio, New York and Pennsylvania, are of great interest. The equivalency and distribution of the formations are discussed, and the age of the oil-bearing beds, and some new views and facts are brought out. Mr. Lesley states that the Catskill sandstone does not thin out westward in New York, as heretofore described, but that it continues into Ohio, and that it includes the "Rock-City" conglomerate of Chatauqua Co., N. Y.; also, that the conglomerate under the Coal measures, to which the Rock-City conglomerate has been referred, "seems nowhere to reach the New York State line, even in outlying patches."

The Chemical Report of Mr. M'Creath contains descriptions and proximate analyses of bituminous coals of many localities, and analyses of various iron ores, limestones and fire clays. It states that the average amount of water in the bituminous coals analyzed is only 1·03 per cent; the average of ash about 5·38 per cent; of phosphorus, ·014 per cent; of volatile combustible matter from bituminous coals of Clearfield Co., 23·64 per cent, of Centre Co., 23·81, of Jefferson Co., 32·60, of Armstrong Co., 34·99 per cent; of fixed carbon in coals of Clearfield and Centre Cos., 68·97; of sulphur in 34 coals from Clearfield Co., 1·36 per cent.

4. *The Vertebrata of the Cretaceous Formations of the West;* by E. D. Cope. 304 pp. 4to, with 57 plates. Report of the U. S. Geological Survey of the Territories by F. V. Hayden, U. S. Geologist in charge, and under the authority of the Department of the Interior. Vol. II. Washington, 1875.—Professor Cope's Report is another of the great works on science due to researches

* These West Rutland fossils are not rare and inconspicuous. Guided by the Rev. A. Wing to the localities he had discovered, I found the rock over the *central* part of the valley in some places full of them, and other specimens less distinct occur in the western margin of the valley; Mr. Wing has observed them also on the eastern margin. The famous marble quarries of the valley are in the intermediate portion of the limestone formation where the metamorphism was more complete. J. D. D.

connected with the Geological Survey of the Territories under the charge of Dr. Hayden. The volume takes up only the Vertebrates of the Cretaceous, leaving those of the Tertiary for a later Report. Each subject, owing to the great number of species discovered in the beds, is a very large one; and the latter will make, as the Preface states, two such volumes. These two are in addition to the quarto volume, in the same series, by Dr. Leidy. The work aims to mention all the species thus far discovered in the Cretaceous west of the Mississippi, and to describe in full those made known by the author. Professor Cope, in an introductory chapter presents his views "on the significance of paleontological science;" then treats in Part I of the classification and distribution of the Cretaceous deposits of the West; in Part II, gives "Descriptions of the Cretaceous Vertebrates of the West;" and in Part III, introduces a Synopsis of the known Cretaceous Vertebrates of North America. The 57 plates of illustrations are full of figures, and well engraved.

The whole number of species of Reptiles in the American Cretaceous beds is stated as follows: Dinosaurs, 18; Pterosaurs, 4; Crocodilians, 14; Sauropterygia (Plesiosaurs, etc.), 13; Testudinates, 48; Pythonomorphs (the Mosasaur tribe), 50 = 147. Of the last tribe, 15 species occur in the Greensand of New Jersey, 7 in the Rotten limestone of Alabama, 26 in Kansas, and one from each, North Carolina, Mississippi and Nebraska. Only four are known from Europe.

Professor Cope, besides bringing out his own large contributions to the subject, mentions also those of Dr. Leidy and Professor Marsh, yet not always in a way to do them full justice. He appears to have forgotten one of his statements, when penning the note to page 124, on *Clidastes propython.* The note reads as follows:

"Professor Marsh (American Journal of Science and Arts, 1872, p. 454,) quotes me as assigning ten cervical vertebræ with articulated hypapophyses to this species. This I have not done, but state (Synopsis of the Extinct Batrachia and Reptiles of North America, p. 221,) that it possesses six such vertebræ. Professor Marsh's statement, and consequent supposition that he first determined the number of cervical vertebræ in the genus Clidastes, are the result of a misapprehension."

But Professor Marsh sustains his remark (this Jour., ii, p. 454, 1872) by reference to page 218 of Cope's Synopsis, where Professor Cope, in drawing out the characters of the genus "Clidastes" from "especially the nearly complete skeleton of *Cl. propython,*" says: "Hypapophyses exist on the ten cervical vertebræ," thus recognizing *ten* as the number. And on page 221 of Cope's Synopsis (the page he refers to) there is nothing that sets this aside. Professor Cope, in view, as he says, of the fact that "a considerable number of the vertebræ [in *Cl. propython*] has been lost," gives on that page the following enumeration of the [*by him*] *known* vertebræ: Atlas and axis, 2; cervicals, 6; dorsals, 15;

and next adds, under the line *dorsals*, 15, "at least to be added to this series, 10," making the sum "33." No correction of the previous statement as to the total number of cervical vertebræ is made or suggested.

In the catalogue of works and memoirs on American Cretaceous Reptiles, headed LITERATURE OF THE SUBJECT (pp. 51, 52, 53), Professor Cope has omitted to mention several highly important contributions by others: for example, Dr. Leidy's memoir of 1865, *on Cretaceous Reptiles of the United States*, a quarto of 135 pages, illustrated by 20 plates; a paper by the same author, *on Elasmosaurus* (Proceedings of the Acad. Nat. Sci. Philad., 1870, p. 9); another *on Discosaurus and its allies* (ibid., p. 18), and another *on Hadrosaurus and its allies* (ibid., p. 67); also, the following of Professor Marsh's papers: *Notice of some New Mosasauroid Reptiles* (this Journ., II, xlviii, 392, 1869); *on a New Species of Hadrosaurus* (ibid., III, iii, 301, 1872), and *Note on Rhinosaurus* (ibid., III, iv, 147, 1872). Again, in his *Synopsis of the known Cretaceous Vertebrata of North America*, constituting Part III of the volume, several Cretaceous Reptiles described by others are omitted, and also the following four species of Cretaceous birds described by Professor Marsh: *Graculavus velox*, of New Jersey (this Journal, III, iii, p. 353, 1872); *G. pumilus*, of New Jersey (ibid., p. 364); *G. agilis*, of Kansas (ibid., v, 1873), and *Palæotringa vagans*, of New Jersey (ibid., iii, 366). J. D. D.

5. *Description of new Species of Fossil Plants from Alleghany Co., Virginia; with remarks on the rocks seen along the Chesapeake and Ohio Railroad, near the White Sulphur Springs, Greenbrier Co., West Virginia;* by F. B. MEEK. 19 pp. 8vo. Proceedings of the Washington Philosophical Society. Read before the Society, June 15, 1872. (Received Dec. 8, 1875).—The fossil plants described by Mr. Meek are from Lewis's Tunnell, and occur in the lower part of the Subcarboniferous, near its junction with the upper Devonian. The species are *Lepidodendron scobiniforme* M., *Cyclopteris Lescuriana* M., *C. Virginiana* M., *C. Alleghaniensis* M., besides an undetermined *Stigmaria* and some doubtful *Carpolithes*.

6. *Coal plants of Tinkiako in Southern Shensi in China.*—AD. BRONGNIART has determined the following plants from the southern part of Shensi, one of the western provinces of China (Bull. Geol. Soc. France, 408, 1874): *Pecopteris Whitbyensis*, two species of *Sphenopters*, a leaf of a *Zamia* near *Zamites distans*, fragments of *Lycopodites Williamsoni*, a species of *Palissya*, and also *Bayera dichotoma* Fr. Braun. The species are nearest to the Jurassic plants of Whitby, and not Carboniferous. Subcarboniferous fossils are described from the same region by M.M. Paul Fischer and Bayan (ibid., p. 409 and pl. 16), who report, from shales, the following: *Spirifer lineatus* Mart sp., *Athyris ambigua*, *Meekella Garnieri* (n. sp.), *Productus Davidi* (n. sp.), *P. costatus* Sow., var *cœlestis*, and *Bellerophon tangentialis* Phill.

In this connection, it is to be noted that the coal plants of Chaitung, west of Pekin, obtained by R. Pumpelly, and described by Dr. Newberry (Geol. Res. in China, etc., Smithson. Contrib., No. 202, 1867,) are referred by the latter to the Trias; they embraced the species *Pterozamites Sinensis* Newb., *Podozamites lanceolatus* Lindl., *Pod. Emmonsii* Newb., (*P. lanceolatus* of N. Carolina, Emmons), *Sphenopteris orientalis* Newb., *Pecopteris Whitbyensis* Brongn., *Hymenophyllites tenellus* Newb., *Taxites spatulatus* Newb. Von Richthofen, on the contrary, concluded, from the conformability of the coal-bearing beds to others below containing Paleozoic fossils, that the coal of China (this Journal, II, i, 410, 1870), was for the most part Carboniferous.

7. *The Dawn of Life, being the History of the oldest known Fossil Remains, and their relations to Geological Time and to the development of the Animal Kingdom;* by J. W. Dawson, LL.D., F.R.S., etc. 240 pp. 12mo, with plates and wood-cuts. London, 1875. (Hodder and Stoughton.)—This volume contains a complete account of the history of the discovery of the Eozoon, and of its structure and nature as developed by Dr. Dawson, Prof. Carpenter, and others. The facts described are illustrated by excellent figures; and one of them, facing page 35, representing an Eozoon mass, looks exceedingly like a form of coral—the Stromatoporæ—to which group it was referred by Logan before its interior structure was studied. The subject discussed is of profound geological importance, since it bears on the question as to the first expression of the animal idea in an organism, and the volume is therefore one of great interest. The Eozoon is referred by the author to the section of the Rhizopods containing the Foraminifers, and to the division of the Foraminifers called *Perforata*, to which the *Nummulinidæ*, *Globigerinidæ* and *Lagenidæ* belong, which have calcareous skeletons penetrated by pores. An inferior division, called the *Imperforata*, have calcareous membranous or arenaceous skeletons without pores.

8. *Geographical and Geological Surveys*; by J. D. Whitney. 96 pp. 8vo. From the North American Review for July and October, 1875. Cambridge, 1875. (Welch, Bigelow & Co.)—Professor Whitney in these papers brings to bear the results of his wide experience as a geographical and geological explorer, in a discussion of the objects, methods, and purposes of such surveys, and gives some account of their history in this and other countries. Much information is presented on the topographical maps issued by foreign governments, and on those in progress and needed at home. The history of geological exploration in the United States is treated with considerable detail and with discrimination. The volume is one to which all may go for information and judicious advice as to the ends accomplished by State surveys, and the means required to secure from them the greatest good to the people.

9. *Descriptive Catalogue of the specimens in the Museum of Melbourne, illustrating the rock system of Victoria;* by G. H. F. Ulrich, M.E., F.G.S. 108 pp. 8vo. Melbourne, 1875.—Besides

the detailed description of the individual specimens in the museum, this little book contains some remarks upon the different kinds of rocks of Victoria and their relations, which give it something more than a local interest. A considerable number of analyses are given, especially for the igneous rocks.

10. *Geology of Illinois.*—The last volume of the series of reports connected with the Geological survey of Illinois under Mr. Worthen is now in the binder's hands.

11. *Geological map of the United States and Canada.*—In a few days, a Geological chart of the United States (east of the 104th meridian) and Canada, by Prof. F. H. BRADLEY, will be on sale by Messrs. Ivison, Blakeman, Taylor & Co., 138 and 140 Grand street, New York, the publishers of Professor Dana's works on Geology. Its size is 24 inches by 16. It contains all the detail and accuracy possible on a chart of this size in the present state of the science. The geological areas are well distinguished by a judicious system of lining, instead of by colors, and hence the chart will be afforded, as we understand, at the low rate of one dollar each. It should be in the hands of all students in geology, and is absolutely indispensable to every teacher.

12. *Einleitung in die Krystallberechnung;* von Prof. CARL KLEIN, Erste Abtheilung. 208 pp. 8vo. Stuttgart, 1875.—Prof. Klein develops the subject of Crystallography from the standpoint of Quenstedt, according to whom the relations of the planes of a crystal are shown by the lines in which they are projected upon a given plane of projection. He does not confine himself to the somewhat unwieldy formulas of Quenstedt, however, but makes all calculations of axial relations and parameters by means of spherical triangles in the manner employed by von Kobell. The author has worked out with much care and completeness the solutions of the various problems which arise, and accompanies each with an example performed in full, so that the student cannot fail to comprehend the method. E. S. D.

13. *On Troilite;* by Dr. J. LAWRENCE SMITH.—A paper on troilite by Dr. Smith was read before the French Academy of Sciences on the 22d of November last. The author shows by new and careful analyses that troilite, or the sulphide of iron of meteorites, has the composition he has before obtained for it, represented by the formula FeS, and not that of pyrrhotite (Fe^7S^8) to which species it is referred by M. Saint Meunier in a communication to the Academy of March, 1874. He observes that the specific gravity of troilite, 4·813, also separates it from pyrrhotite, a selected specimen of the latter affording him only 4·642. As this meteoric sulphide is found imbedded in a mass of iron, "the natural supposition is that the sulphur would be saturated with the iron." Hence, he adds, "troilite like schreibersite, is exclusively a celestial mineral.

Rectification of the Geological map of Michigan, embracing observations on the Drift of the State; by Alexander Winchell. 17 pp. 8vo. Salem, 1875. From Proc. Amer. Assoc. for 1875.

III. Botany and Zoology.

1. Karl Koch, *Vorlesungen über Dendrologie. Lectures on Dendrology*, delivered in Berlin in the winter semester of 1874–75. Stuttgart, F. Enke, 1875, pp. 408, 8vo.—These are the notes of a course of popular lectures by Prof. Koch, on a subject in which he is thoroughly at home. They must have been delightful to hear, as they are pleasant to read, and are full of interesting matter. It is only the first course of a series which is to be continued this winter. The first division, of seven lectures, is a history of landscape gardens and gardening. The second division, of as many more, treats of the structure, growth, and life of trees, of the influence of woods upon mankind, and as regulators of temperature and atmospherical changes. The third division, in four lectures, treats of Coniferous trees,—all in a popular way. Prof. Koch insists that the two willows confounded as forms of the Weeping Willow, are neither of them Persian or Assyrian, except by immigration, but natives of a farther east, i. e., of China and Japan. One of them may have reached Western Asia, however, early enough to have been collected by Tournefort, and so to excuse the error fixed by Linnæus by his name of *S. Babylonica.* But even the last volume of DeCandolle's Prodromus does not rectify it. Notwithstanding Prof. Koch's correction and elucidation, it is likely that popular books and the popular belief will continue to associate the Weeping Willow with the River of Babylon and the hanging harps of the weeping Israelites, although the tree of the Psalm most likely was a Poplar. We believe it was Ker Porter who remarked that willows were to be found along the river, but only as low shrubs: upon these nothing larger than a comparatively modern musical instrument associated with the name and nation could well be hung. When the course is completed we shall look for an English edition of these lectures upon tree-lore. A. G.

2. *Insectivorous Plants;* by Charles Darwin. With illustrations. London: Murray. New York: D. Appleton & Co.—This long expected work appeared last autumn, was immediately reprinted by the American publishers, and before this time has been so widely read that no detailed account of it is at all necessary. Its main topic is *Drosera* or Sundew, upon which the vast number and diversity of the observations and experiments—at once simple, sagacious, and telling—which it records, are about as wonderful as the results. As to the latter, it is established beyond question that the common Sundews are efficient fly-catchers; that the stalked glands, or tentacles, as Mr. Darwin terms them, are sensitive and turn inward or even in other required directions in response to irritation; that they equally respond and move in obedience to a stimulus propagated from a distance through other tentacles and across the whole width of the leaf; that the sensitiveness belongs only to the glands and tips of the tentacles, but

is propagated thence down their stalks and across the blade of the leaf through the cellular tissues; that they accurately and delicately discriminate animal or other nitrogenous matter from anything else; that the glands absorb such matter; that when excited by contact, or by the absorption of nitrogenous matter by the viscid enveloping liquid, an acid secretion is poured out and a ferment analogous to pepsin, the two together dissolving animal matter; so that the office and action of these glands are truly analogous to those of the glands of the stomach of animals. Finally that animal or nitrogenous matter, thus absorbed and digested in the glands, is taken in, and conveyed from cell to cell through the tentacles into the body of the leaf, was made evident by ocular inspection of the singular changes in the protoplasm they contain. So particularly have the investigations been made and so conscientiously recorded, that the account of those relating to one species of Sundew, *Drosera rotundifolia*, fills 277 pages of the English edition, or more than half of the book. After all it ends with the remark: "and we see how little has been made out in comparison with what remains unexplained and unknown." The briefer examination of six other Sundews follows, some of them equally and others less efficient fly-catchers and feeders.

Dionæa is next treated, but with less detail. Indeed, except as to the particular nature of the secreted digesting fluid, there is little in this chapter that had not been made out or already become familiar here. That the secretion has digestive powers, and that it is re-absorbed, along with whatever has been digested, is now proved beyond reasonable doubt. That the motor impulse is conveyed through the cellular parenchyma, and not through the vascular bundles, or spiral vessels, and that the latter do not originate the secretion, as Rees and Wills in a recent paper seem to suppose they must, appears to be shown by the facts, and was antecedently probable. "The wonderful discovery made by Dr. Burdon Sanderson is now universally known: namely, that there exists a normal electrical current in the blade and footstalk, and that when the leaves are irritated the current is disturbed in the same manner as takes place during the contraction of the muscle of an animal." The conclusion here needs to be checked by parallel experiments, to see whether the same reversion of current does not take place whenever a part of any leaf or green shoot is forcibly bent upon itself.

Aldrovanda vesiculosa, of the *Drosera* family, "may be called a miniature aquatic *Dionæa*;" for, as discovered by Stein in 1873, "the bilobed leaves open under a sufficiently high temperature, and when touched suddenly close." Being submerged, their prey is confined to minute aquatic animals. For want of proper material and opportunity, Mr. Darwin was able to follow up only for a little way the observations of Stein and Cohn,—enough, however, to show that it also captures and consumes animals, but perhaps avails itself of the nitrogenous matter only when passing into decay.

Drosophyllum, a rare representative of the order, confined to Portugal and Morocco, grows on the sides of dry hills near Oporto; so that, as to station, it is the very counterpart of *Aldrovanda.* Its leaves are long and slender, in the manner of our *Drosera filiformis*, and are covered with much larger glands. To these flies adhere in vast numbers. "The latter fact is well known to the villagers, who call the plant the 'fly catcher,' and hang it up in their cottages for this purpose." Mr. Darwin found the glands incapable of movement, and their behavior in some other respects differs from that of *Drosera*; but they equally secrete a digestive juice. Insects usually drag off this secretion instead of being fixed on the glands by it; but their fate is no better; for as the poor animal crawls on and these viscid drops bedaub it on all sides, it sinks down at length exhausted or dead, and rests on a still more numerous set of small sessile glands which thickly cover the whole surface of the leaf. These were till then dry and inert, but as soon as animal matter thus comes in contact with them, they also secrete a digestive juice, which, as Mr. Darwin demonstrated, has the power of dissolving bits of coagulated albumen, cartilage, or meat, with even greater readiness than that of *Drosera.*

Mr. Darwin next records various observations and experiments upon more ordinary glandular hairs of several plants. To certain Saxifrages his attention was naturally called, on account of the presumed relationship of *Droseraceæ* to this genus. He declares that "their glands absorb matter from an infusion of raw meat, from solutions of nitrate and carbonate of ammonia, and apparently from decayed insects. To such plants the vast number of little insects caught may not be useless, as they may be to many other plants (tobacco, for instance) with sticky glands, in which Mr. Darwin could detect no power of absorption. The prevalent idea, that glandular hairs in general serve merely as secreting or excreting organs, and are of small or no account to the plant, must now be reconsidered. Those of the common Chinese Primrose (*Primula Sinensis*) although indifferent to animal infusions, were found to absorb quickly both the solution and vapor of carbonate of ammonia. Now, as rain-water contains a small percentage of ammonia, and the atmosphere a minute quantity of the carbonate or nitrate, and as a moderate-sized plant of this primrose was ascertained, (by estimate from a count on small measured surfaces by Mr. Francis Darwin) to bear between 2½ to 3 millions of these glands, it begins to dawn upon us that these multitudinous organs are neither mere excrescences nor outlets, nor in any just sense insignificant.

Mr. Darwin next investigates the densely crowded short glandular hairs, with their secretions, which form the buttery surface of the face of the leaves of *Pinguicula*, the Butterwort. He finds that the leaves of the common Butterwort have great numbers of small insects adhering to them, as also grains of pollen, small seeds, &c.; that most substances so lodged or placed, if yielding

soluble matter to the glands, excite them to increased secretion; but that if non-nitrogenous the viscid fluid poured out is not at all acid, while if nitrogenous it invariably has an acid reaction and is more copious; that in this state it will quickly dissolve the muscles of insects, meat, cartillage, fibrin, curds of milk, &c.; that when the surface of a plane leaf is fed, by placing upon it a row of flies along one margin, this margin, but not the other, folds over within twenty hours to envelope them; and when placed on a medial line, a little below the apex, both margins incurve. He concludes "that *Pinguicula vulgaris*, with its small roots, is not only supported to a large extent by the extraordinary number of insects which it habitually captures, but likewise draws some nourishment from the pollen, leaves, and seeds of other plants, which often adhere to its leaves. It is therefore partly a vegetable as well as an animal feeder." The leaves in one or two other species were found capable of greater and more enduring inflection, and the glands excitable to increased secretion even by bodies not yielding soluble nitrogenous matter.

The aquatic type of this family is *Utricularia;* and the bladder-bearing species of this genus are to *Pinguicula* nearly what *Aldrovanda* is to *Dionæa* and *Drosera*—the bladders imprisoning minute aquatic animals, by a mechanism almost as ingenious as that of *Dionæa* itself. Observations of the same kind were made in this country by Mrs. Treat, of Vineland, New Jersey, before Mr. Darwin's investigations were made known. These submerged aquatic stomachs, ever deluged with water, apparently do not really digest their captures, but merely absorb the products of their decay.

The same must in all probability be said of such Pitcher-plants as *Sarracenia* and *Darlingtonia*, which Mr. Darwin merely alludes to at the close of his volume but does not treat of. *Nepenthes*, however, according to Dr. Hooker's investigations, has attained a higher dignity, and converted its pitcher into a stomach. This parallelism, and this higher and lower mode of appropriating organic products by each of the three well-marked carnivorous families of plants, are highly suggestive.

In concluding this notice of a book for which we have no room to do justice—but which is sure to be in the hands of many interested readers—there is somewhat to be said in regard to the discovery of the lure in some of our Sarracenias. We have by degrees to discover our discoverers. In this Journal, only so far back as the number for August, 1873, is a notice of the discovery of a sweet secretion at the orifice of the pitcher of *Sarracenia flava*, by Mr. B. F. Grady, of Clinton, North Carolina (in the article by an oversight called "Mr. Hill"), which effectively lures flies to their destruction. This statement, made in a letter, had been for several months in our hands, awaiting the opportunity of confirmation, when an allusion to the same thing appeared in the English edition of LeMaout and Decaisne's System of Botany, without reference to any source, and on inquiry we learned that the authority

for the statement was forgotten. But early in the following year, when the monograph of the order appeared in the last volume of DeCandolle's Prodromus, a reference was found to a paper by Dr. Macbride in the Transactions of the Linnæan Society. His observations (made upon *S. variolaris*), it appears, were communicated to Sir J. E. Smith, read before the Linnæan Society in 1815, and published soon after. They are referred to by his surviving friend and associate, Eliott, in his well-known work, and therefore need not have gone to oblivion, or needed rediscovery here in our days by Mr. Grady and Dr. Mellichamp, the latter greatly extending our knowledge of the subject. Probably the main facts were all along popularly known in the regions these species affect, and where their use as fly-traps is almost immemorial. But the *gist* of these remarks is, that a colleague has just called our attention to an earlier publication than that of Dr. Macbride, viz., an article on "Certain Vegetable Muscicapæ," by Benjamin Smith Barton (one of our botanical fathers), published in Tilloch's Philosophical Magazine, for June, 1812. Among other matters not bearing directly upon this point, he says of *Sarracenia*, without reference to any particular species: "A honeyed fluid is secreted or deposited on the inner surface of the hollow leaves, near their *faux* or opening; and this fluid allures great numbers of the insects which they are found to contain into the ascidia."

Here is earlier publication by three years. Yet we suspect that Dr. Barton knew little about it at first hand, and we find clear evidence that he had not anticipated Dr. Macbride. All his references have an indefiniteness quite in contrast with Dr. Macbride's narrative; he says that "some if not all the species of the genus appear to possess a kind of glandular function," without mentioning those that have it, or the absence of it in the only species growing around him at the north; and he adds that he "was entirely unacquainted with this curious economy . . . when I published the first edition of my Elements of Botany, and even when I printed the appendix (in vol. i) to the second edition of this work." Now his paper is dated September 11, 1811; and the volume referred to, as just printed, is dated 1812. But Macbride states that his observations were chiefly made 1810 and 1811; he corresponded intimately with Eliott, through whom, if not directly, his observations would probably find their way at once to the Philadelphia naturalists. A. G.

3. *The Movements and Habits of Climbing Plants;* by Charles Darwin. Second edition, revised, with illustrations. London: Murray. 1875. pp. 208.—This most interesting treatise was read to the Linnæan Society over ten years ago and published in the ninth volume of its Journal, in 1865. There was a separate issue, which has long been exhausted. It is now carefully re-edited, considerably added to, and reproduced as an independent volume. It will no doubt be much sought after, as the topic and treatment of it are peculiarly fascinating and instructive, and the

book is throughout readable. Mr. Darwin's gift for making things clear without technicalities, is as great as that of many writers for enveloping them in technical obscurity. Having given an account of this essay upon its original appearance, we need only mention the republication, which will be within the reach of all, as an edition is about to be issued by Appleton & Co. A. G.

4. *Hæckel's Ziele und Wege der heutigen Entwickelungsgeschichte.*—The controversy carried on by Hæckel in defence of some of his pet theories has gradually assumed a more and more personal character. The criticisms in his *Generale Morphologie* were sharp, but justifiable from his standpoint. In the *Schöpfungsgeschichte*, they had already become sensational. In the *Anthropogenie* his sketches of contemporaries and his analysis of their work assumed a still more unpleasant emphasis; and this has now culminated in a pamphlet entitled "Ziele und Wege der heutigen Entwickelungsgeschichte."

It is difficult to characterize this production without indulging in the same style of epithets which Hæckel uses so freely. From the title we expected one of those brilliant chapters, which, however untrustworthy, are full of suggestions; we were sadly disappointed to find it filled simply with abuse of His, Gœtte, Ludwig, Reichert, Michelis, Agassiz and others.

We shall not fill the pages of this Journal with countercharges or explanation; a man so skilled in coarse invective, who has risen to such a height of intolerance, is proof against anything so tame as fact or argument. This is not the place to refute his absurd claims to omniscience, and his assumptions of immunity for the very offences he so mercilessly condemns. According to Hæckel it is an unpardonable sin for His or Gœtte to give a false interpretation of what they have seen, or for Ludwig and Reichert to differ from him in his explanation of protoplasm; but when he himself, to suit a purpose, deliberately falsifies facts, when he manufactures with names and figures an archetype which never existed, we are called upon to be grateful that a corner of the veil shrouding creation is lifted, and that we are fortunate enough to live at a time when so infallible an interpreter of its mysteries, has taken up his abode at Jena.

In the concluding pages, devoted to Agassiz and Michelis, all the bitterness of his bigotry and dogmatism are poured forth against the latter, while he stoops so low in his attacks on the former as to pick up all the baseless slanders ever circulated by his enemies during his life. With scientific productions like these we have no concern. A few more such criticisms, and Hæckel's claim to be recognized as a true and devoted student of nature will be forgotten. In its place, he will gain, what he seems to seek, the front rank among scientific demagogues. A. AG.

5. *Memoirs of the American Association for the Advancement of Science.* I. *Fossil Butterflies;* by S. H. Scudder. 99 pp. 4to, with three plates. Salem, 1875.—The sum of one thousand dollars was given in Aug., 1873, by Mrs. Elizabeth Thompson, of

New York City, to the American Association, to be used, according to the directions of the Standing Committee, for the promotion and publication of original investigations by members of the Association.

The memoir by Mr. Scudder is the first paper published by the Thompson Fund, and is one which well deserves so prominent a place. Mr. Scudder has had especial advantages in this work, having with one or two trifling exceptions, as he states, "either personally inspected all the fossils described within recent times as butterflies, or having procured new and excellent original drawings of them." He has brought together in this volume all that has been published on this group of fossils whether of text or illustration, presenting thus a complete account of our knowledge of these insects. After the detailed descriptions of the genera and species of fossil butterflies, the author discusses various related topics; their comparative age, the probable food plants of Tertiary caterpillars; the present distribution of butterflies most nearly allied to fossil species, and so on. The plates were executed in Paris, and are beautiful examples of the best lithographic work.

IV. ASTRONOMY.

1. *Small Planets recently discovered.*—In the number of this Journal for August last (p. 158), a table of the planets so far as No. 146 was given. Nine planets have been since discovered, making fifteen during the year.

No. 147	was	discovered by	Schulhof, at Vienna, July 10th.
148	"	"	Prosper Henry, at Paris, Aug. 8th.
149	"	"	Perrotin, at Toulouse, Sept. 21st.
150	"	"	Watson, at Ann Arbor, Oct. 19th.
151	"	"	Palisa, at Pola, Nov. 1st.
152	"	"	Paul Henry, at Paris, Nov. 2d.
153	"	"	Palisa, at Pola, Nov. 2d.
154	"	"	Prosper Henry, at Paris, Nov. 4th.
155	"	"	Palisa, at Pola, Nov. 8th.
156	"	"	Palisa, at Pola, Nov. 22d.
157	"	"	Borelly, Marseilles, Dec. 1.

It has been suggested by Tietjen that No. 152 may prove to be Dike (99). If so the later numbers will need to be changed to correspond. H. A. N.

2. *The Cape Catalogue of* 1,159 *Stars, deduced from observations at the Royal Observatory at the Cape of Good Hope, under the superintendence of* E. J. STONE.—The Royal Observatory at the Cape of Good Hope was established in 1820. The leading idea was to found a first class observatory in the southern hemisphere for work of a character similar to that of the Greenwich Observatory in the northern hemisphere. The observations were to be made with instruments of the same class, and the result to be drawn up in the same form, in order that the whole might constitute two corresponding series, capable of comparison in all their parts. No opportunity of making observations capable of improving our knowledge of the refraction of the atmosphere, was to be

neglected. Under the successive superintendency of Fallows, Henderson, and Sir Thomas Maclear, the latter of whom arrived at the Cape in 1834, and of E. J. Stone, who arrived in 1870, the work of the Observatory has been carried on under very adverse circumstances, and the results thus far accomplished have somewhat disappointed the earlier expectation, and compare unfavorably with those achieved by the energies of Gilliss and Gould. Mr. Fallows was able to publish a small catalogue of star places; Mr. Henderson was able to detect the parallax of *Alpha Centauri*, and to produce a very valuable catalogue of very accurate places of a number of stars. Sir Thomas Maclear seems to have concentrated his energies during many years upon the measurement of an arc of the meridian, of the value of which work there can be but one opinion; but this was allowed to disorganize the other work of the observatory to such an extent that, as Mr. Stone states, he in 1870, found himself with a very limited staff, unexpectedly confronted with the results of 36 years of miscellaneous observations in all stages of reduction, nothing completed, and nothing available for publication and use, without a considerable expenditure of time and labor. Under these circumstances, he has judged it best to pay especial attention to the later years of observation, and has compiled a catalogue of places of 1,159 stars observed in the years 1856 to 1861; all of them made with transit circle, an instrument similar in all respects to the Greenwich instrument, which has been in use since 1851. The Cape Catalogue of Mr. Stone, is accompanied by a comparison of the right ascensions of the clock stars as observed at Greenwich and the Cape of Good Hope, by means of which comparison some systematic errors are brought to light, which are, however, very small in extent, and may be themselves attributed to the effect on the clock of rapid changes of temperature in the evenings during December, January, and February. The latitude of the observatory must, he thinks, still be considered as uncertain.

The printing of the work, which was done at Cape Town, does not suffer by comparison with similar work in England.

C. ABBE.

3. *Observatory in the Pyrenees.*—An observatory has been established on the Pic de Midi, similar to that on the Puy de Dome, and chiefly through the efforts of General Nansouty.—*L'Institut*, Dec. 1.

IV. Miscellaneous Scientific Intelligence.

1. *Reports on the Meteorological, Magnetic, and other Observations of the Dominion of Canada for the calendar year ending December* 31, 1874.—In this volume the Minister of Marine and Fisheries, Honorable A. J. Smith, has given in full a reprint of the tri-daily simultaneous observations made at a large number of stations throughout the Dominion of Canada, together with tables of monthly and annual means, resultant direction, and velocity of the wind, etc. In consideration of the exceedingly small annual

appropriation at the disposal of Professor Kingston, Superintendent of the Meteorological office of the Dominion, it would seem that the contributions to meteorology by that State are highly creditable. Prof. Kingston states that regular weather reports are telegraphed from fifteen Canadian stations to the Weather Bureau at Washington, in exchange for which a few reports are sent from the United States by telegraph, and a large number by mail. The only station in Canada at present furnished with self-recording apparatus is that at St. Johns College, at Winnipeg, where, by private munificence, an anemograph has been set in operation by the Bishop of Ruperts Land. With reference to Montreal, which ranks as one of the chief stations, it is stated that the position of McGill College, on account of its proximity to the mountains, is singularly ill adapted for anemometric observations, on which account an anemometer was, in August, 1874, erected on a pole on the summit of the mountain, and connected by telegraph wires with the recording apparatus in the Observatory which is 550 feet lower down on the mountain. There are in Canada thirty-five stations to which storm warnings are occasionally forwarded from Toronto. It would appear that these storm warnings do not give so much satisfaction in the Canadian ports as do the corresponding ones in the United States; this deficiency is explained by Professor Kingston as due in an important degree to the errors of incompetent observers, or to the failure in the prompt delivery of reports to the central office, but perhaps especially to the neglect of the agents at the drum stations to report the results of all storm warnings; and he makes a suggestion, which it would be highly desirable to carry into effect in the United States, and, indeed, in all countries, to the effect that all light-house keepers, and all other government officials at inland places, as well as on the coast, be required, as a part of their regular duty, to report promptly by mail, in a very brief manner, the circumstances attending any gale that may occur in their neighborhood. Among the appendices to Professor Kingston's report, is the annual report of the Director of the Observatory at Quebec, who states that the new observatory and house were finished early in May, and the instrument, etc., were removed thither. This observatory contains rooms for the equatorial, the transit and computing room and photographic, and is directly adjacent to the dwelling of the Director, Commander E. D. Ashe. The principal work of the equatorial consists in taking photographs of the sun's surface from which to determine the time of rotation, inclination of its axis, etc. The principal routine work of the observatory, in a commercial point of view, is to give the correct time to the shipping. The time ball is now dropped by electricity, and the method has been brought to a considerable state of perfection. Commander Ashe has also entered heartily into the work of determining latitudes and longitudes of points in the Dominion. C. A.

2. *Mt. St. Elias.*—The recent measurements of Mr. W. H. Dall, Acting Assistant U. S. Coast Survey, of the height of Mt. St. Elias, make it 19,464 feet. The memoir,—a part of the Coast Survey

Between Yokohama and Honolulu the depth is remarkably uniform, averaging 2,858 fathoms, and the material of the bottom is Report for 1875—is illustrated by a map and also a plate containing two views of the Mountain. The views, taken at distances of 53 and 24 miles, evidently have the vertical scales very greatly increased, as compared with the horizontal, but how much is not stated.

3. *Sea-bottom and Zoology of the deep sea: the Challenger's Observations;* by WYVILLE THOMSON.—A gigantic Hydroid was obtained June 17th, in the North Pacific, 34° 37′ N., 140° 32′ E., at a depth of 1,875 fathoms, where the temperature was 1°·7 C. and the bottom gray mud. The species seemed to belong to *Monocaulon* of Sars, a Corymorpha-like solitary polyp; it measured from tip to tip of the expanded tentacles 9 inches, and the height of the hydroid was 7 feet 4 inches. Another was taken July 5, in 37° 41′ N., 177° 4′ W., at 2,900 fathoms, the bottom red clay, but with manganese nodules, the weight of which tore the trawl. The hydroid is too delicate in texture to bear the rough change from the bottom to the surface. The tentacles of the proximal range are about 100 in number and 4 inches long. The sporosacs are in close tufts at the base of the tentacles. This gigantic *Corymorphoid* was associated on June 17th, with Ophidoids, Macrurids, Scopellids, several Gasteropods, Crustaceans related to *Dorippe*, *Galathea*, *Caridids*, and a fine *Scalpellum*, a few Annelids, many Echinoderms (*Brisinga*, *Phormosoma*, *Ophiurids*, *Holothurids*), and on July 15th, there were some *Aphroditids*, a sea-urchin related to *Diadema*, Holothurids, sponges.

The clayey material of the bottom, brought up June 17, was in a peculiar concretionary state, and bored by an Annelid of the Aphrodite group, some of which were still in the burrows.

In a sounding of June 28th, of 2,800 fathoms, a Rhizopod-like form was obtained, between the Radiolarians and the Foraminifers, its test siliceous as in the former, but the shape as in the latter; their tests were extremely abundant in the "red-clay." There were also obtained a *Scalpellum*, a number of Annelids, Echinoderms of the genera *Pourtalesia*, *Archaster*, *Brisinga*, *Antedon*, a *Cornularia*, specimens of *Fungia symmetrica*, some *Actiniæ*. On July 2d, in 2,050 fathoms, the bottom was a light brownish ooze, with many *Globigerina* shells; several specimens of an undescribed *Hyalonema* were brought up.

The cold water which fills up the trough of the Pacific is regarded by Professor Thomson "an indraught from the Southern Sea," as in the Atlantic; and in both oceans the bottom water is constantly moving northward. The temperature of the water for the first thousand fathoms in the Pacific, in the corresponding latitude of 35° N., is much lower than in the Atlantic. Further, in the Atlantic the temperature sinks gradually, though very slightly, through the last thousand fathoms to the bottom, while in the Pacific, the minimum temperature of 1·7 C. is reached at a depth not greater than 1,400 fathoms, and from that depth to the bottom the temperature is the same.

"red clay," somewhat grayer than the typical "red clay," containing some pumice, numerous siliceous shells, the proportion of which increases with the depth, and scarcely a trace of carbonate of lime (although the water swarms with "ooze-forming" Foraminifers). The pumice was often penetrated with peroxide of manganese, and concretions of the same oxide were abundant in the "red clay." These concretions are rounded or mammillated, fibrous-concentric in structure, and often have a nucleus of some foreign body, as pumice, a shark's tooth, or some other organic relic; and in one case a fragment of a Hexactinellid sponge was preserved as a beautiful fossil at the middle. "The singular point is the amount of this manganese formation and the vast area which it covers." Life was found to be, "although not very abundant in species by no means meagre," in the North Pacific at depths between 2.000 and 3,000 fathoms, all the larger invertebrate groups being represented. In one dredging, at a depth of 3,125 fathoms, a small sponge was obtained. a species of *Cornularia*, an *Actinia*, an Annelid in a tube and a Bryozoon. "We were again struck with the wonderful uniformity of the fauna at these depths—if not exactly the same species, very similar representatives of the same genera existing in all parts of the world."—*Extracts from articles in Nature of Oct.* 28 *and Nov.* 25.

The Challenger arrived at Valparaiso November 19th, on her way home.

4. *Report of an Expedition up the Yellowstone River, made in* 1875; by Lt. Col. J. W. FORSYTH and Lt. Col. F. D. GRANT, under the orders of Gen. P. H. SHERIDEN. 17 pp. 8vo, with a map. Washington, 1875.—This expedition succeeded in navigating the Yellowstone River to a distance of 483 miles above its mouth, the only obstacles to farther progress being the excessively rapid current. It was found that the water of the Yellowstone is deeper than that of the Missouri, above the point where the two rivers join. Some interesting views accompany the report, and also a large map of the river, by Lieut. R. E. Thompson.

5. *Preliminary Report of Explorations in Nebraska and Dakota in the years* 1855, '56, '57; by Gen. G. K. WARREN, U. S. A. 125 pp. 8vo. Washington, 1875.—This is a reprint of the report of Gen. Warren, originally published in 1858, and noticed in this Journal II, xxvii, 378. The present volume is issued in view of the general interest now felt in the Black Hills country, the original report being practically inaccessible.

6. *Atti della Societa Toscana di Scienze Naturali Residente in Pisa.* Vol. I. Parts 1 and 2. 146 pp. roy. 8vo. Pisa. 1875.—These first publications of the Tuscan Society of Science in Pisa, contain papers on the mammalian fauna of the Pliocene of Tuscany, by C. I. F. Major; on the fishes of the same by R. Lawley; on Eocene corals of Friule by D'Achiardi; on the natrolite (savite) and analcite of Pomaja, by D'Achiardi, and other papers geological and zoological, by Meneghini, De Stefani, Baraldi, Richiardi, with one botanical, Sulla teoria Algolichenica, by G. Arcangeli.

OBITUARY.

Emile Kopp, Professor of Chemistry in the Polytechnic School of Zurich, died on the 30th of November at the age of fifty-nine years. He was an Alsatian by birth, and held a chair in the University of Strasbourg previous to 1848. He took an active part in the revolution of that year, and was one of the Deputies who escaped to Switzerland at the time of Louis Napoleon's *coup d'etat.* While residing in Switzerland he was appointed Professor of Chemistry at Lausanne, but he left the country voluntarily, with the other French exiles, when their rendition was demanded by the French government. Passing into England, Kopp supported himself for several years as a private tutor at Manchester, and at the same time familiarized himself with the great chemical industries of that vicinity. The influence of his sojourn in England was strikingly manifest throughout his subsequent career. After the lapse of several years he was permitted to return to France on the parol of one of the Senators of that period (probably M. Dumas) who pledged himself that the returned exile should in no way interfere with the imperial government. On reaching Paris, Kopp opened a private laboratory for instruction in applied chemistry, which was maintained for several years, and was always filled with students. From this laboratory he was called to the charge of extensive works for the manufacture of steel at Saverne, in the east of France, which place he left some years later to assume the chair of applied chemistry in the University of Turin, whence he was soon called to Zurich.

For many years Kopp exhibited great literary activity, and he is probably best known to the generality of chemists from his remarkable compilations relating to the history and progress of the coal-tar colors and of the madder colors. He was largely instrumental in writing Hofmann's famous report on the Chemical Products and Processes of the International Exhibition of 1862, as was duly acknowledged by Prof. Hofmann. This report, as is well known, has served as a model upon which most subsequent reports upon chemical matters have been based. But, in spite of much writing, he accomplished a great deal of work in the way of research, notably in respect to the coloring matters just mentioned, and in other departments of calico-printing. He devised novel processes for making soda from salt, and for the recovery of sulphur from soda-waste, and published numerous observations upon a great variety of subjects.

His familiarity with the methods and processes of technical chemistry, as applied in different countries, was very great, and his judgment of them was singularly sound and impartial. He labored untiringly to inform himself of all improvements and discoveries in the domain of chemical technology, and was doubtless at the time of his death one of the best teachers of applied chemistry that has ever lived.

Wheatstone.—Sir Charles Wheatstone died at Paris, on the 19th of October, at the age of seventy-three years.

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ART. VI.—*Sir William Edmond Logan.**

ON the 22nd of June, at Castle Malgwyn, Llechyrd, South Wales, Canada's veteran geologist passed from his labors. For several years his health had been failing, and he felt more and more the need of rest and change of climate. Accordingly, in August, 1874, he crossed to the mother country, intending to pass the winter there, and then to return to his work in the spring. But rest and a more genial clime were unavailing, and now—kindest of friends, most indefatigable of workers for science and for his country—he is no more!

William Edmond Logan was born at Montreal, in 1798. He was of Scottish parentage, and his father, after a residence of many years in Canada, returned to Scotland, and purchased an estate near Stirling, known as Clarkstone. His education was begun at Mr. Skakel's school, in this city, and completed at the High School and University of Edingburgh.

On leaving college he betook himself to mercantile pursuits, and we find that in 1818 he entered the counting-house of his uncle, Mr. Hart Logan, of London. Here he remained for about ten years, and here, it is said, he first became fond of geology, making geological excursions into the country whenever opportunity offered.

In 1829 he paid a visit to Canada; but, returning the same year, took up his residence at Swansea, in South Wales, where he was appointed manager of a copper-smelting establishment, and of coal mines, in which an uncle of his was interested. In

* Obituary notice read before the Natural History Society of Montreal, October 25th, 1875.

1834, he made a tour through France and Spain, visiting many of the mines in the latter country, and making many observations on the geology of the regions through which he passed. In 1838, his uncle dying, Mr. Logan resigned his position at Swansea. But the nine years he spent here were well-spent years; for not only had he gained a practical knowledge of mining and metallurgy, which afterwards proved of the greatest value to him, but had done a large amount of very excellent geological work—work which caused Dr. Buckland, of Oxford, to say of him, "He is the most skillful geological surveyor of a coal-field I have ever known." During his stay at Swansea, he was an active worker for the interests of the Royal Institution of South Wales. He was Honorary Secretary and Curator of the geological department, and the Institution is indebted to him for valuable collections of minerals and metallurgical products, besides books, drawings and laboratory apparatus. The whole of his geological work in South Wales he placed gratuitously at the disposal of the Ordnance Geological Survey of Great Britain, and it was not only gladly accepted, but published "without alteration," and made the basis of future work in that region. Concerning it, Sir H. T. De la Beche afterwards wrote as follows:

"Prior to the appearance of the Geological Survey in that part of the country, Mr. W. E. Logan had carefully investigated it, and at the meeting of the British Association for the Advancement of Science, held at Liverpool in 1837, he exhibited a beautifully executed map of it.

"The work on this District being of an order so greatly superior to that usual with geologists, and corresponding, in the minuteness and accuracy of its detail, with the maps and sections executed by the Ordnance Geological Survey, we felt desirous of availing ourselves of it, when Mr. Logan most handsomely placed it at our disposal. Having verified this work with great care, we find it so excellent that we shall adopt it for that part of the country to which it relates, considering it but fair and proper that Mr. Logan should obtain that credit to which his labors so justly entitle him.

"His sections are all levelled and measured carefully with proper instruments, and his maps are executed with a precision only as yet employed, except in his case, on the Ordnance Geological Survey; it being considered essential on that survey, for the right progress of geology, and the applications to the useful purposes of life, that this accuracy and precision should be attained."

In 1840, Logan read a paper before the Geological Society of London, in which he explained, for the first time, the true relation of the *Stigmaria* underclays to the overlying beds of coal,

showing that the underclay was the soil in which the plants grew which were afterwards converted into coal. Of the 100 thick and thin coal-seams in the South Wales coal-field, he found that not a single one was without an underclay, and the inference appeared to be that there was some essential connection between the production of the one and the existence of the other. "To account," said he, "for the unfailing combination by drift, seems an unsatisfactory hypothesis; but whatever may be the mutual dependence of the phenomena, they give us reasonable grounds to suppose that in the *Stigmaria ficoides* we have the plant to which the earth is mainly indebted for those vast stores of fossil fuel which are now so indispensable to the comfort and prosperity of its inhabitants."

So much did he become interested in this subject that in the following year (1841) he crossed to America, and visited the coal-fields of Pennsylvania and Nova Scotia, in order to ascertain whether the same conditions existed there. Such he found to be the case; and in the following spring he read an interesting paper before the Geological Society, the object of which, to use his own words, "was to state the occurrence immediately below the coal-seams of America of the same *Stigmaria* beds as had been observed below those of South Wales, and to show the importance of this prevailing fact." Shortly after his return from America, he also visited coal-seams in the neighborhood of Falkirk, Scotland, there too, finding the *Stigmaria* clays beneath the coal.

It was during his visit to Nova Scotia, in 1841, that he discovered in the Lower Coal-measures of Horton Bluff the foot-prints of a reptilian animal—a discovery which, perhaps, failed to attract as much attention as it deserved, although it was the first instance in which any trace of reptiles had been detected as low down in the geological scale as the Carboniferous. The winter of 1841–42 was also spent in Canada, and the facts were obtained for a paper on the packing of ice in the St. Lawrence, which was subsequently read before the Geological Society of London.

Such, briefly, was the career of Logan previous to his appointment as Director of the Geological Survey of Canada. Already he had acquired a reputation in Britain as a geologist, and had given himself the best of trainings for the work upon which he was about to enter on this side of the Atlantic. But what was meantime passing in Canada? * * * *

"In July, 1841, in the first United Parliament, a petition from the Natural History Society of Montreal, praying for aid to carry out a systematic geological survey of the Province, was presented by Mr. B. Holmes. It was referred to a select committee consisting of Messrs. Holmes, Neilson, Quesnel, Mer-

rit, and the Hon. Mr. Killaly, but it was not reported on. A similar petition was presented by Mr. Black, from the Literary and Historical Society of Quebec, which was read. The government took up the matter, and on the motion of the Hon. B. Harrison, the sum of £1,500 sterling for the purpose of a survey was introduced into the estimates."*

Lord Sydenham dying in 1841, it fell to his successor, Sir Charles Bagot, to appoint a Provincial Geologist. Sir Charles referred the matter to Lord Stanley, Secretary of State for the Colonies, and His Lordship, on recommendation of Murchison, De la Beche, Sedgwick, and Buckland, offered the position to Mr. Logan in the spring of 1842.

Logan was now thoroughly in love with geology, and seeing in Canada the grandest of fields for original research, at once accepted. Still he well understood the difficulties which lay before him, and shortly afterwards addressed the following words to De la Beche: "You are aware that I have been appointed by the Provincial Government of Canada to make a Geological Survey of that Colony. The extent and nature of the territory will render the task a most laborious one; but I am fully prepared to spare no exertion of which I am capable to render the work, when it is completed, satisfactory to those who have instituted the examination and creditable to myself. * * No one knows better than yourself how difficult it would be for one person to work with effect in all the branches of so extensive a subject. To carry out the field-work with vigor, to reduce all the sections with the requisite degree of accuracy, and map the geographical distribution of the rocks, to collect minerals and fossils, and to analyze the one, and by laborious and extensive comparisons, to determine the geological age of the other, is quite impossible without a proper division of labor. * * In Canada, all the expensive means of palæontological comparison have yet to be brought together. There is no arranged collection of fossils, and no such thing as a geological library to refer to."

Arriving in Canada late in August, 1842, Logan devoted several months to making a preliminary examination of the country, and to collecting information with regard to the topographical work which had been accomplished. This was done entirely at his own expense. In December, he returned to England to fulfill engagements there, but came out again in the following spring. During his visit to the old country, he was so fortunate as to secure the services of Mr. Alexander Murray, a gentleman who afterwards proved himself an invaluable assistant and friend, and who has contributed largely to our knowledge of the geology of Canada, and, more recently, to that of Newfoundland.

*From Scobie's Canadian Almanac for 1851.

Reaching Halifax on the 20th of May, Logan spent several weeks in examining portions of the coal-fields of Nova Scotia and New Brunswick, and it was at this time that he made his section of the Coal Measures at the South Joggins, which, as has been truly said, is "a remarkable monument of his industry and powers of observation." It gives details of nearly the whole thickness of the coal formation of Nova Scotia, or 14,570 feet, including 76 beds of coal and 90 distinct *Stigmaria* underclays. Shortly after his visit to the Joggins, he wrote to a friend as follows: "I never before saw such a magnificent section as is there displayed. The rocks along the coast are laid bare for thirty miles, and every stratum can be touched and examined in nearly the whole distance. A considerable portion has a high angle of inclination, and the geological thickness thus brought to view is very great. I measured and registered every bed occurring in a horizontal distance of ten miles, taking the angle of dip all the way along." And again, in a letter to De la Beche written in the spring of 1844, referring to the Joggins section, he says: "Since my return from field-work, I have reduced all the measurements and made out a vertical column. It occupies fifty-four pages of foolscap, closely written, and you will be astonished at the details in it."

Reaching Gaspé early in July, the summer and autumn were spent in making an examination of the coast, while Mr. Murray was at work in the Upper Province, examining the country between Lakes Huron and Erie. The Gaspé peninsula had been selected by Mr. Logan as the field for his first operations, as it was thought that outlying patches of the Carboniferous might be found to exist there, and the government was especially anxious to ascertain whether there was any truth in the reported occurrence of coal.

The following season, the work in Gaspé was continued, the Director being this time accompanied by Mr. Murray, who, in 1845, again carried on the work, while Mr. Logan was engaged in explorations on the Upper Ottawa and Mattawan. Altogether, during the three seasons, 800 miles of the Gaspé coast were examined, and several sections made across the peninsula, from the St. Lawrence to Bay Chaleur. No coal was found, but many geological facts of importance were accumulated, and a large amount of topographical work accomplished in what was previously almost a *terra incognita.*

"Living the life of a savage, sleeping on the beach in a blanket sack with my feet to the fire, seldom taking my clothes off, eating salt pork and ship's biscuit, occasionally tormented by mosquitoes,"—such is the record which Logan has left us of his Gaspé life, the foretaste of what was to be endured for many years. From early dawn till dusk he paced or paddled, and yet

his work was not finished, for while his Indians—often his sole companions—smoked their pipes round the evening fire, he wrote his notes and plotted the day's measurements.

To give details of his work during the many remaining years of his life would be to write a book; and all that we can do here is to trace briefly what his movements were, at the same time calling special attention to those of his labors which have given him a world-wide fame.

The summer of 1846 found him studying the copper-bearing rocks of Lake Superior. These he showed to consist of two groups of strata, the "upper" and the "lower," the latter of which was seen at Thunder Bay to rest unconformably upon chloritic slates belonging to an older series, to which the name of Huronian was subsequently given. This older set of rocks, which he had already observed, in 1845, on Lake Temiscamang, he had ample opportunity of studying in 1848, when he devoted several months to an examination of the Canadian coast and islands of Lake Huron, where the formation attains—as shown by Murray—a thickness of 18,000 feet.

The seasons of 1847 and 1849, and a portion of that of 1848, were employed in studying the rocks of the Eastern Townships. Part of these were shown to be a prolongation of the Green Mountains of Vermont, and to consist of altered Silurian strata instead of "Primary strata," as was previously supposed by American geologists. In 1849 also, a short time was spent in an examination of the rocks about Bay St. Paul and Murray Bay, where coal had been reported to exist. The member for Saguenay County had previously made application to the Legislature for means to carry on boring operations in the vicinity of Bay St. Paul, but before his request was granted it was deemed advisable to obtain the opinion of the Provincial Geologist. By this means the Government was saved a large and useless expenditure of money.

In 1850 an examination was made of the gold-bearing drift of the Chaudière, and the auriferous district found to extend over an area of between 3,000 and 4,000 square miles. Most of the year, however, was devoted to the collection of specimens for the London Exhibition of 1851, at which Mr. Logan acted as Juror. His visit to England at this time must have been for him an agreeable change. After a lapse of eight years to meet again with men like De la Beche, Murchison and Lyell, to hear from their own lips of the strides which science had been making, and in turn to tell of all that he had himself seen and done; surely this was a treat that none but the scientific man can understand who has long been well-nigh deprived of the society of brother scientists. For him, however, there was little relaxation from labor, for he toiled early and late in order that the

Canadian minerals might be displayed to the best advantage. And every one knows the result—the collection elicited universal admiration, and Mr. Logan received a highly complimentary letter of thanks from the Prince Consort, and was elected a Fellow of the Royal Society, his name having been proposed by Sir Roderick Murchison.

Returning to Canada in August, before the close of the Exhibition, his explorations were renewed with undiminished vigor, and the remainder of the season devoted to an examination of the rocks in the county of Beauharnois, where the Potsdam sandstones had afforded those curious tracks of crustaceans to which Owen gave the name of Protichnites, and to a further study of the Chaudière gold region. During the winter he again visited England to attend to the distribution of a portion of the Exhibition collection which was to be left there, and to see to the return of the remainder.

In 1852 an examination was made of a strip of country on the north side of the St. Lawrence, extending from Montreal to Cape Tourmente below Quebec. The distribution of the fossiliferous rocks was accurately determined, and several excursions were made into the hilly "metamorphic country" to the north. In his report on this season's operations, published in 1854, Logan for the first time designated the rocks comprising these hills as the "Laurentian series," substituting this for "metamorphic series," the name which he had previously employed, but which, as he says, is applicable to any series of rocks in an altered condition.

The following season was spent among the Laurentian hills of Grenville and the adjoining townships, a field which proved so attractive that he afterward returned to it in 1856 and 1858. Nearly the whole of 1854 was occupied in making preparations for the Exhibition which was to take place at Paris in the following year, and to which Mr. Logan was to go as one of the Canadian Commissioners. It was in the autumn of 1854 also, that a select committee was appointed by the Canadian Government to inquire into the best method of making the information acquired by the Geological Survey more readily accessible to the public. A lengthy report on the subject—indeed on the entire working of the Survey—was published, and the evidence which it contains is of a most flattering character, both as regards the Director and those associated with him.

Then came the Paris Exhibition of 1855, at which the representation of the economic minerals of Canada was so complete and the arrangement so admirable that the collection attracted universal attention. This in itself Logan would have regarded as amply repaying him for his trouble; but greater honor was in store for him. The Imperial Commission presented him with

the grand gold medal of honor, and the Emperor of the French made him a Chevalier of the Legion of Honor. Early in the following year (1856) he was knighted by Queen Victoria, and received from the Geological Society of London the Wollaston Palladium Medal in recognition of his distinguished labors in geology. Long previous he had won the confidence and esteem of his fellow-countrymen in Canada, but this seemed to be a fitting time to testify to him their appreciation of his worth. Accordingly, on his return to Montreal, the citizens presented him with a testimonial on which were engraved the words:

"In commemoration of his long and useful services as Provincial Geologist in Canada, and especially his valuable services in connection with the Exhibition of all Nations in London in 1851, and in Paris in 1855, by which he not only obtained for himself higher honor and more extended reputation, but largely contributed in making known the natural resources of his native country."

The Natural History Society of Montreal presented him with an address, and made him an honorary member, while the members of the Canadian Institute of Toronto, of which Sir William was the first President, had his protrait painted and hung up in their hall. They also presented him with an address expressive of their affectionate esteem and respect. Sir William's reply to this was so full of feeling, and so highly characteristic, that we give a portion of it: "Whatever distinctions," said he "may be bestowed on us at a distance, it is upon the respect, esteem, and confidence shown us at home, that our happiness and satisfaction must chiefly depend. I can assure you with sincerity that the honor conferred upon me, when you elected me the first President of the Institute, was one highly prized, although the circumstances of a distant domicile, and the intent pursuit of the investigations with which I am charged, rendered it extremely difficult for me to be of much use in your proceedings. . . . . It is a fortunate circumstance for me that my name should be connected with an act of grace on the part of Her Majesty, which serves to confirm your feeling in regard to the fact that as Canadians we enjoy a full share in the honors and privileges of British subjects. And I am proud to think that it was perhaps more because I was a Canadian, in whom the inhabitants of the Province had reposed some trust, that the honor which has been conferred upon me by Her Majesty was so easily obtained. That I am proud of the honors which have been bestowed upon me by the Emperor of France, in respect to my geological labors, and also by my brother geologists in England, there can be no doubt. But I have striven for these honors because I have considered they would tend to promote the confidence which the inhabitants of the Province have

reposed in me, in my endeavors to develop the truth in regard to the mineral resources of the Province; and in this work none could have been more interested in my success than the members of this Institute."*

In August, 1857, the American Association for the Advancement of Science held its annual meeting in Montreal, and for several months previous Sir William was hard at work getting his museum in readiness to receive his brother geologists. Owing largely to his untiring exertions, the meeting was a most successful one. He himself read two interesting papers, one on the "Huronian and Laurentian Series of Canada," and another on the "Sub-division of the Laurentian Rocks of Canada" After the business of the Association was concluded, accompanied by Professor Ramsay, who had come over to represent the Geological Society of London, and Professor Hall, he made a Geological tour through New York State. Returning from this trip, he spent the autumn months among the Laurentian Rocks of Grenville. Here too, as already mentioned, he continued to work during the season of 1858.

For several years after this, his time was much taken up with the preparation and publication of the *Geology of Canada* and its accompanying Atlas, the former of which appeared in 1863, and the latter in 1865. Before these could be completed, however, many facts had to be added to the stock already obtained, and besides a large amount of geological work among the Laurentian rocks of Grenville and the rocks of the Eastern Townships, a personal examination of many parts of the country, as well as of portions of the New England States, was rendered necessary.

In 1862, Sir William was again present, in the capacity of Juror, at the London International Exhibition, and again displayed a large and interesting collection of economic minerals. Another opportunity of seeing his scientific friends in Britain was also afforded him in 1864, when he went to London to superintend the engraving of the Atlas already mentioned. In 1866, a geological collection was again prepared for the Paris Exhibition of 1867, and Sir William worked so closely in getting up a geological map to accompany it that he is said to have nearly ruined his eyesight. 1868 found him once more on this side of the Atlantic, hard at work in the Pictou coal-field, and the results of this season's work constitute the last of his reports. In 1869, he resigned his appointment to Mr. Selwyn, the present Director of the Survey.

The few remaining years of his life were occupied chiefly with a study of the rocks of the Eastern Townships and portions of New England: but, unfortunately, the conclusions at which he arrived concerning them were not published.

* Can. Journal, New Series, vol. i, p. 404.

No man has done as much as Sir William Logan to bring Canada before the notice of the outside world, and no man is more deserving of being held in remembrance by the people. Just as statesmen or generals have risen up at the moment of greatest need to frame laws or fight battles for their country, so Sir William appeared to reveal to us the hidden treasures of Nature, just at a time when Canada needed to know her wealth in order to appreciate her greatness For rising nations require to know what their resources are. He possessed rare qualities—qualities, which, combined, eminently fitted him for his work. He was strong in body, of active mind, industrious and doggedly persevering, painstaking, a lover of truth, generous, possessed of the keenest knowledge of human nature, sound in judgment, but always cautious in expressing an opinion.

He belonged to that school of geologists—unfortunately not so numerously represented as it ought to be—whose motto is, "Facts, then theories," and was wholly above rasping down facts to make them fit theories. As a consequence, he rarely had to un-say what was once said; and this is why he so thoroughly gained the public confidence. So long as he felt that he was in the right, he held to his own views as tenaciously as did ever any true Scot; but if shown to be in the wrong, he knew how to surrender gracefully.

Those who have clambered with him over our log-strewn Laurentian hills know well what were his powers of endurance. He never seemed to tire, never found the days long enough. His field-books are models of carefulness, replete with details, and serve as an example of the painstaking way in which he did all his work. They were written in pencil, but regularly inked in at night, when the camp fire was often his only light. In addition to his field-book proper, he frequently kept a diary, and delighted to jot down little every-day occurrences, or sketch objects of interest—for the hand that could so well wield a hammer, could also guide a pencil and produce drawings of no mean artistic skill. His descriptions of his backwoods experiences are often very amusing, and we cannot resist giving a specimen. He had been traveling through the forest for two months and had suddenly come upon the house of a settler called Barton, whose good wife was justly alarmed when Sir William and party entered her dwelling. Sir William describes his appearance, on this occasion, as follows:—"We are all pretty-looking figures. I fancy I cut the nearest resemblance to a scarecrow. What with hair matted with spruce gum, a beard three months old, red, with two patches of white on one side, a pair of cracked spectacles, a red flannel shirt, a waistcoat with patches on the left pocket,—where some sulphuric acid, which I carry in a small vial to try for the presence of lime in the rocks, had

leaked through,—a jacket of moleskin, shining with grease, and trowsers patched on one knee in four places, and with a burnt hole in the other: with beef boots—Canada boots, as they are called—torn and roughened all over with scraping on the stumps and branches of trees, and patched on the legs with sundry pieces of leather of divers colors; a broad-brimmed and round-topped hat, once white, but now no color, and battered into all shapes. With all these adornments, I am not surprised that Mrs. Barton, speaking of her children, and saying that here was "a little fellow frightened of nothing on earth," should qualify the expression by saying, "but I think he's a little scared at *you*, Sir."

It was not alone in the field that Sir William was busy. His office work was often most arduous, and during the earlier years of his directorship, in addition to preparing his annual report, he even kept the accounts, entering every item of expenditure, so that he could at any time show exactly how every penny of the public money placed at his disposal had been spent. He also tells us that, with his own hands, he made, at that time, four manuscript copies of the Annual Report of Progress, often reaching more than one hundred printed pages—one copy for the Government, one for the House of Assembly, one for the Legislative Council, and one for the printer.

His manner of living was simple as it was solitary. Like his four brothers, he never married, nor does he seem to have formed many intimate friendships. Still every one who knew him loved him and respected him, and if you go the length and breadth of all the land, you will everywhere hear his praises, alike from rich and poor.

He peculiarly possessed the power of inspiring others with his own enthusiasm; not only those in his employ, but even uneducated farmers and backwoodsmen—men who, as a rule, are rather sceptical about the advantages to be derived from geology.

Though possessed of private means, he spent little upon himself; not that he was parsimonious, but he cared not for fashion or luxury. But with him Science never pleaded her needs in vain. The first grant of the Legislature, to make a geological survey of the Colonies, was £1,500—an amount which, Sir William quaintly remarked, was but a drop of what would be required to float him over twenty-five degrees of longitude and ten of latitude. This was, of course, very soon spent, and not only this, but at the end of the second year the Survey was £800 in his debt, and he had no guarantee whatever that his money would be returned to him. Since then the Survey has been constantly indebted to him for books, instruments, and other aids, and the building on St. James street, now used for office purposes, was built by him, two years ago, and rented to the

Government for about half the amount which he could have obtained from other tenants. To Logan also, McGill University owes much; for, in 1864, he founded and endowed the "Logan Gold Medal" for an honor course in geology and natural science, and, in 1871, gave $19,000, which, together with $1,000 given by his brother, the late Mr. Hart Logan, forms the endowment of the "Logan Chair of Geology."

Since resigning his position as Director of the Geological Survey, he has carried on explorations at his own expense, and, at the time of his death, arrangements had been nearly completed for putting down a bore-hole in the Eastern Townships, at a cost of $8,000; as he thought that this would enable him to prove the truth of his views with regard to the age of the metamorphic rocks there. . . . .

Sir William was the first to give us any definite information about those wondrous old Laurentian rocks which form the backbone of our continent. He showed us that they were older than the Huronian, and that they consisted of a great series of metamorphosed sedimentary rocks, which are divisible into two unconformable groups, with a combined thickness of not less than 30,000 feet. The great beds of limestone which he found in the lower series, the plumbago, the iron ores, the metallic sulphurets, all seem to point to the existence of life in the Laurentian days; but the discovery of *Eozoon Canadense* made conjecture give place to certainty. Now we *know* that the world of that far-off time was not a lifeless world. Life, whatever that may be, had been joined to matter.

The first specimens of *Eozoon* were found by Dr. James Wilson, of Perth; but at the time of their discovery were regarded merely as minerals. In 1858, however, Mr. J. McMullen, of the Geological Survey, discovered other specimens, the organic orig n of which so struck Sir William that in the following year—four years before their true structure and affinities were determined by Dawson and Carpenter—he even exhibited them as fossils at the meeting of the American Association.

In widely extending our knowledge of the early geological history of the earth, Sir William has done a great work; indeed this may be regarded as his greatest work. Its importance has everywhere been recognized, and the name Laurentian, which he chose for the rocks at the bottom of the geological scale in America, has crossed the Atlantic, and is now applied to the homotaxial rocks of Europe. Sir Roderick Murchison, who dedicated the fourth edition of "Siluria" to Sir William Logan, even substituted Laurentian for "Fundamental Gneiss," the name which he had given to the rocks of the West Highlands of Scotland. "I at first," says Murchison, "termed them 'Fundamental Gneiss,' and soon after, following my distinguished friend

Sir William Logan, I applied to them his term, 'Laurentian,' and thus clearly distinguished them from the younger gneissic and micaceous crystalline rocks of the Central and Eastern Highlands, which were classed as metamorphosed Lower Silurian."

Logan was not a voluminous writer, and during the later years of his life writing was a great effort to him. Occasional papers from his pen have appeared in the *Transactions of the Geological Society* of London, in the *Canadian Naturalist* and the *Canadian Journal*, and some of these have already been referred to; but most of what he has written is to be found in the *Reports of Progress* annually submitted to the Government, and in that invaluable book, the *Geology of Canada*, which is, to a large extent, a digest of what is contained in the reports published previous to 1863. He sometimes expressed himself quaintly, but everything he wrote is clear and exceedingly concise.

In addition to being a Fellow of the Royal Society and of the Geological Societies of London and Paris, he was a member of numerous other learned societies both in Europe and America. At the time of his death, and for many years previous, he was one of our Vice-Presidents; but though frequently solicited to accept the office of President, he always declined,—not on account of any lack of interest in the Society, but he felt his time was too fully occupied to permit of his successfully discharging the Presidential duties. We have already alluded to some of the medals which were awarded to him; but it may be mentioned that altogether he was the recipient of more than twenty, including two from the Royal Society.

And now, in concluding, let me say to you, my friends, if you would do honor to the memory of that noble old man, who fought so long, so bravely, for his country, for science, for you, then honor the cause for which he fought: strive with all your might to advance the interests of that cause, and to raise up a superstructure befitting the solid foundation which Logan has laid. He himself even hoped to build the superstructure; but his anticipations were not realized, for life was not long enough, and we must take up the mantle which he has dropped.

B. J. HARRINGTON.

ART. VII.—*On Recent Researches in Sound;* by WM. B. TAYLOR.

[Continued from page 41.]

IV.

THE communication of Professor Reynolds "On the Refraction of Sound by the Atmosphere," is in two parts; the first of which considers "The effect of Wind upon Sound," and the second part "The effect of variations of Temperature." The experiments were all made in "a flat meadow of considerable extent;" and the apparatus employed "consisted of an electrical bell mounted on a case containing a battery. The bell was placed horizontally on the top of the case, so that it could be heard equally well in all directions; and when standing on the ground, the bell was one foot above the surface." An anemometer was also used to determine the velocity of the wind. (Proceedings of the Royal Society; republished in the L. E. D. Phil. Mag., for July, 1875, vol. l, p. 67.)

The experiments were made on four different days, the 6th, 9th, 10th, and 11th of March, 1874; and on the last two days the ground was covered with snow, which furnished an opportunity of comparing the effect of different surfaces on the range of Sound. Additional experiments were made on the 14th of March.

[1.] "On all occasions the effect of wind seems to be rather against distance than against distinctness. Sounds heard to windward [that is *against* the wind] are for the most part heard with their full distinctness; and there is only a comparatively small margin between that point at which the sound is perceptibly diminished, and that at which it ceases to be audible." (Phil. Mag., p. 63.)

[2.] The sound of the alarm-bell was always heard "farther with the wind than at right-angles to its direction; [contrary to the old observation of De La Roche in 1816,—which was obviously an exceptional one;] and when the wind was at all strong, the range with the wind was more than double that at right angles. . . . . *With* the wind, over the grass the sound could be heard 140 yards, and over the snow 360 yards, either with the head lifted or on the ground; whereas at right-angles to the wind, on all occasions the range was extended by raising either the observer or the bell." (p. 68.)

[3.] When the wind was light the sound beyond the distance of 20 yards, was much less audible at the ground than a few feet above it; and when inaudible in every direction at standing height, the sound could be distinctly recovered by mounting a tree. The same result was obtained by raising the alarm-bell

upon a post 4 feet high; which while materially increasing the range of the sound—even in the direction of the slight wind, in all other directions doubled the range. This is explained by Professor Reynolds, by the continual waste and destruction of the sound waves which pass along the rough surface of the ground or grass, causing the waves immediately above to diverge continually downward, to be in like manner absorbed; the effect of which is to gradually weaken the sound more and more, as the waves proceed; so that even "when there is no wind, the distant sounds which pass above us are more intense than those we hear." (p. 68.)

[4.] Whatever therefore tends to gradually bend downward the sound rays will increase their sensible range. Professor Reynolds found by observations with the anemometer that the velocity of the wind increased from the ground upward; (pp. 63, 64) and hence it must give greater rapidity to the upper portion of the sound waves in the direction in which it is blowing and cause their impulses to continually tip downward. "This was observed to be the case on all occasions. In the direction of the wind when it was strong, the sound could be heard as well with the head on the ground as when raised, even when in a hollow with the bell hidden from view by the slope of the ground; and no advantage whatever was gained either by ascending to an elevation, or raising the bell." (p. 68.)

[5.] "Elevation was found to affect the range of sound against the wind in a much more marked manner than at right-angles. Over the grass no sound could be heard with the head on the ground at 20 yards from the bell, and at 30 yards it was lost with the head 3 feet from the ground, and its full intensity was lost when standing erect at 30 yards. At 70 yards when standing erect the sound was lost at long intervals, and was only faintly heard even then; but it became continuous again when the ear was raised 9 feet from the ground, and it reached its full intensity at an elevation of 12 feet." (p. 69.) The same results were obtained with snow on the ground, excepting that the sound was heard somewhat lower, being less dissipated or absorbed by the surface contact. At 160 yards the bell was inaudible—even at an elevation of 25 feet, and the sound was supposed to be hopelessly lost; but at a further elevation of 33 feet from the ground, it was again heard; while at 5 feet lower it was lost. At the proper elevation the sound appeared to be as well heard against the wind as with it, at the same distance. These last two observations very strikingly correspond with and confirm the observations of Henry [3], and [4].

[6.] "The least raising of the bell was followed by a considerable intensifying of the sound;" and while it could be heard only 70 yards when resting on the ground, (i. e., one foot

high), when set on a post 5 feet high, it could be heard 160 yards, or more than twice the distance,—the sound-beams evidently rising faster at or near the ground, than they do higher up. (p. 69.) "The intensity of the sound invariably seemed to waver, and as one approached the bell from the windward side, the sound did not intensify uniformly or gradually, but by fits or jerks." This is supposed to be the result of the more or less curved sound rays crossing each other at a small angle and producing an "interference." (p. 70.)

A subsequent experiment was made on the 14th of March, during a strong west wind, its velocity at an elevation of 12 feet being 37 feet per second, at 8 feet, 33 per second, and at one foot from the ground (there being no snow on the grass) 17 feet per second. While the results as to varying range fully confirmed the previous experiments, the raising of the bell caused the sound to be heard even better against the wind than in the direction of the wind. (p. 71.) This curious circumstance is explained by Professor Reynolds as "due to the fact that the *variation* in the velocity of the air is much greater near the ground, than at a few feet above it;" and "when the bell is raised the rays of sound which proceed horizontally will be much less bent or turned up than those which go down to the ground; and consequently after proceeding some distance these rays will meet or cross, and if the head be at this point they will both fall on the ear together, causing a sound of double intensity. It is this crossing of the rays also which for the most part causes the interference" just mentioned. (p. 71.)

Professor Reynolds concludes that "these experiments establish three things with regard to the transmission of sound: 1. That when there is no wind, sound proceeding over a rough surface is more intense above than below. 2. That as long as the velocity of the wind is greater above than below, sound is lifted up to windward and is not destroyed. 3. That under the same circumstances it is brought down to leeward, and hence its range extended at the surface of the ground. These experiments also show that there is less variation in the velocity of the wind over a smooth surface than over a rough one. It seems to me that these facts fully confirm the hypothesis propounded by Prof. Stokes; that they place the action of wind beyond question; and that they afford explanations of many of the anomalous cases that have been observed." (p. 71.)

[7.] In regard to the second part of the communication, treating of the effect of Temperature differences in refracting sound, Professor Reynolds shows that as "every degree of temperature between 32° and 70° adds approximately one foot per second to the velocity of sound," there must necessarily be an upward flexure of the rays, whenever by reason of any consid-

erable increase of temperature in the lower strata of the air, the lower portion of the sound waves is projected in advance of the upper portion. (p. 71.) Atmospheric vapor also, though exercising but little direct influence on the velocity of sound, "nevertheless plays an important part in the phenomena under consideration; for it gives to the air a much greater power of radiating and absorbing heat, and thus renders it much more susceptible of changes in the action of the sun. . . . . It is a well-known fact that the temperature of the air diminishes as we proceed upward, and that it also contains less vapor. Hence it follows that, as a rule, the waves of sound must travel faster below than they do above, and thus be refracted or turned upward." (p. 72.)

The variation of temperature will be greatest in a quiet atmosphere when the sun is shining. The report of Mr. Glaisher "On eight Balloon Ascents in 1862" showed that "The decline of temperature [upward] near the earth with a partially clear sky is nearly double that with a cloudy sky."* "During the night the variations are less than during the day. This reasoning at once suggested an explanation of the well-known fact that sounds are less intense during the day than at night. This is a matter of common observation, and has been the subject of scientific enquiry." (p. 73.) The opinion must here be hazarded that this familiar phenomenon has first received its true and satisfactory explanation from Professor Reynolds.

Assuming that for a few hundred feet upward, the diminution of temperature on a clear summer day is 1° for each hundred feet, a horizontal sound-ray would be bent up in an arc having a radius of about 20 miles. From a cliff 235 feet high, a sound should be audible from 1½ to 2 miles on the sea, and the ray should then begin to rise above the observer's head. This is shown to accord very closely with the observation of Tyndall [6]. Professor Reynolds after quoting the observation at length, remarks: "Here we see that the very conditions which actually diminished the range of the sound were precisely those which would cause the greatest lifting of the waves. And it may be noticed that these facts were observed and recorded by Professor Tyndall with his mind altogether unbiased with any thought of establishing this hypothesis. He was looking for an explanation in quite another direction. Had it not been so he would probably have ascended the mast and thus

* Mr. Glaisher remarks: "From these results we may conclude that in a cloudy state of the sky, the decline of temperature is nearly uniform up to the clouds; that with a clear sky the greatest change is near the earth, being a decline of 1° in less than 100 feet, gradually decreasing as in the general law indicated in the preceding section, till it requires 300 feet at the height of 5,000 feet, for a change of 1° of temperature." (Rep. Brit. Assoc, 1862, p. 462.)

found whether or not the sound was all the time passing over his head. On the worst day an ascent of 30 feet should have extended the range nearly one quarter of a mile." (Phil. Mag., p. 76.)

V.

The instructive result, brought into view by the foregoing summaries, is that the differences noticed are essentially those of interpretation, and not to any important extent, of observation: an illustration if any were needed, of the high and rare order of imaginative insight requisite to the successful investigation of the more recondite operations of natural law. The differing actions of acoustic reflection and acoustic refraction suggested by the ingenious hypotheses of Humboldt and of Stokes, and espoused respectively by Tyndall and Henry, are probably both operative but their relative importance has yet to be established. It is certain, as already indicated, that some of the phenomena observed lie quite beyond the reach of the acoustic cloud hypothesis.

A particularly interesting case which is claimed with equal confidence for either theory, is the remarkable observation of General Duane, that at Portland, Maine, the steam whistle on Cape Elizabeth, nine miles distant, "can always be distinctly heard" with "the wind blowing a gale directly *toward* the whistle" or against the sound. (L. H. Rep., p. 100.) At Portland Head, about midway between this fog-whistle and the point of observation is another signal,—a Daboll trumpet. While both these signals are better heard with an adverse wind ("a heavy northeast snow storm") than at other times, yet "as the wind increases in force, the sound of the nearer instrument—the trumpet—*diminishes*, but the whistle becomes *more distinct*." (Rep., p. 92.) The abnormal influence of the wind in reversing the order of these two signals is not the least surprising feature of the general phenomenon.

Professor Tyndall believes that this curious observation only "proves the snow-laden air from the northeast to be a highly homogeneous medium;" (Sound, Preface, p. 19,) the intervening air at other times being acoustically less transparent.

Professor Henry supposes "that during the continuance of the storm, while the wind was blowing from the northeast at the surface, there was a current of equal or greater intensity blowing in an opposite direction above, by which the sound was carried in direct opposition to the direction of the surface current;" (Rep., p. 92)—somewhat in the nature of a vertical cyclone. He adds: "The existence of such an upper current is in accordance with the hypothesis of the character of a northeast storm, which sometimes rages for several days at a given

point on the coast without being felt more than a few miles in the interior, the air continuously flowing in below and going out above. Indeed in such cases a break in the lower clouds reveals the fact of the existence above of a rapid current in the opposite direction." (p. 92.)

Professor Henry's attention had been directed to this point as early as 1865, by discovering that a signal was audible against the wind at the mast-head of a vessel, after ceasing to be audible on deck: Obs. [4]. "This remarkable fact at first suggested the idea that sound was more readily conveyed by the upper current of air than the lower, and this appeared to be in accordance with the following statement of Captain Keeney, who is commander of one of the light-house vessels, and has been for a long time on the banks of Newfoundland in the occupation of fishing: 'When the fishermen in the morning hear the sound of the surf to leeward, or from a point toward which the wind is blowing, they take this as an infallible indication that in the course of from one to five hours the wind will change to the opposite direction from which it is blowing at the time.' The same statement was made to me by the intelligent keeper of the fog-signal at Block Island. In these cases it would appear that the wind had already changed direction above, and was thus transmitting the sound in an opposite direction to that of the wind at the surface of the earth." (Rep., p. 92.) The full significance of this idea however was not apprehended until the hypothesis of Professor Stokes (already alluded to) was taken up and considered. This appeared to furnish a satisfactory explanation of the observed effect of an upper current,—not on the actual range, but on the *direction* of the sound waves

Professor Tyndall thus comments on the rival hypothesis of Professor Henry: "In the higher regions of the atmosphere he places an ideal wind, blowing in a direction opposed to the real one, which *always* accompanies the latter, and which more than neutralizes its action. In speculating thus he bases himself on the reasoning of Professor Stokes, according to which a sound-wave moving against the wind is tilted upward. The upper and opposing wind is invented for the purpose of tilting again the already lifted sound-wave downward." (Pref. to Sound, pp. 19, 20.)

The word "invented" is scarcely the most appropriate term for an hypothesis derived from such patient research and careful induction. While in the case considered, the reversed upper wind of a local circulation is rendered so probable by the circumstances presented. it is proper to remark that this condition is not at all essential to the refraction doctrine. The hypothesis of Professor Stokes by no means assumes that "a

sound-wave moving against the wind is tilted upward." (Rep. Brit. Assoc., 1857, pp. 22, 23, of Abstracts.) An opposing wind exercises no sensible influence on either the velocity or the range of sound, nor (if *uniform*) on the direction of sound. Ordinarily indeed, a wind (which may be likened to an aerial river) is retarded at the earth precisely as the current of a stream is, over its bed.* When, however, the mouth of the aerial chimney of ascent is low, it may very well happen that the lower current of air (excepting immediately at the surface of the earth) is considerably swifter than the successive layers of wind above it; and in such a case the effect of the opposing wind will be not to tilt upward the sound-beam, but to tilt it downward. In like manner a "favoring" wind, if more sluggish above, will tilt the sound-beam upward, and thus prove unfavorable to its audibility. In short, the postulate required for acoustic refraction is simply that there shall be a *difference* of amount between the upper and the lower currents of wind. And as this condition is certainly not an unusual one, we have here apparently a true and satisfactory account of the seeming anomalies of sound with reference to the influence of the wind.

But if the natural tendency of a mere diminution of velocity in the upper strata of an adverse wind is thus to bend an advancing sound downward, "a precisely similar effect" as Professor Henry has well remarked, "will be the result but perhaps in a considerably greater degree, in case an upper current is moving in an opposite direction to the lower, when the latter is adverse to the sound." (Rep., p. 107.) In September, 1874, when a signal near Sandy Hook, N. J., was observed to be audible at a greater distance against the afternoon sea-breeze than with it, Professor Henry ascertained by the employment of small toy balloons, that the upper current was opposed to the lower one, and in the direction of the maximum sound range: Obs. [11.] He was enabled thus to demonstrate experimentally the reality of the "ideal wind" which had been so confidently accepted before, from other conspiring intimations.

The critical commentary above cited, which postulates for this doctrine of acoustic refraction the super-position of "an ideal wind blowing in a direction opposite to the real one," as a condition "which more than *neutralizes* its action," quite fails to apprehend its true import. No action analogous to "neutralization" is assumed by the doctrine. There is no solution

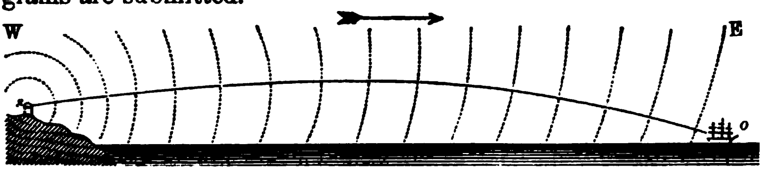
*** Professor Henry determined by experiment in 1865, when the velocity of the wind was not more than six miles per hour, that the speed of the clouds as indicated by their moving shadows, was several times this rate. (L. H. Rep., p. 93.) And Professor Reynolds in 1874, by observations with the anemometer, ascertained that near the ground the retardation of the wind rapidly increased; so that the lower sound rays move more nearly in the arc of a parabola, than of a circle. (Phil. Mag., pp. 64 and 70.)**

of continuity between opposing currents; but every gradation of movement in each successive intermediate stratum. And as it is wholly improbable that the sound-beam *which reaches the observer's ear*, ever passes high enough to approach the upper "ideal wind," nothing is neutralized. Obedient to the law of instantaneous resultants, the beam of acoustic impulse presses on ever at right angles to the wave-surface which is conditioned by compounded factors.

As wide of the mark is the supposition that the upper and opposing "ideal wind" is "for the purpose of tilting again the already lifted sound-wave, downward." As has been just contended, the one wind is as incapable of depressing the sound-wave, as the other is of lifting it.

The misconception culminates in the objection that "Professor Henry does not explain how the sound-wave *re-crosses* the hostile lower current, nor does he give any definite notion of the conditions under which it can be shown that it will reach the observer." (Loc. cit., p. 20.) There *is* no "hostile lower current," since as above pointed out, an opposite wind may be just as favorable to the propagation of sound, as a concurrent one.

To give, however, a more definite notion of the conditions under which it can be shown that the sound-wave will reach the observer without crossing currents, the accompanying diagrams are submitted.

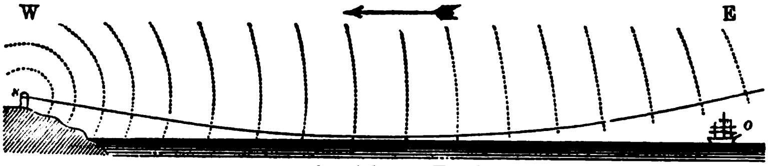


1.—Favoring Wind.

Fig. 1 exhibits the more ordinary effect of a *favorable* wind in depressing the beam of sound: *s* being the signal-station, and *o* the point of observation; the wind blowing from *W.* to *E.* As the spheroidal wave-faces become more pressed forward above by the freer wind (assuming it to be retarded at the surface by friction), and as the direction of the acoustic beam is constantly normal to the successive aerial surfaces of impact, it follows that very minute differences of concentricity in the successive waves, will by constant accumulation gradually bend the line of dynamic effect downward, as shown in the sketch on a very exaggerated scale. Of the sound rays below the line represented, some will by reflection from the sea, reach the observer's ear and thus increase the sound.

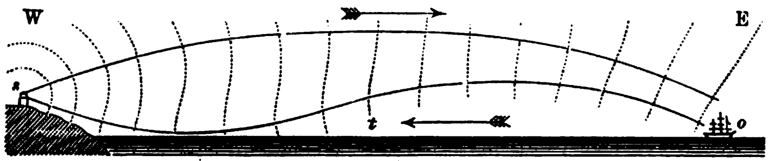
Fig. 2 represents the ordinary effect of an *opposing* wind here blowing from *E.* to *W.* The wave faces being more resisted

above by the freer contrary wind (assuming as before a surface retardation), the sound-beams are curved upward, and the lowest ray that can reach the distance of the observer at *o*, is that which touching the surface of the sea is gradually so tilted up-



2.—Adverse Wind.

ward that it passes above the ear of the listener, leaving him practically in an acoustic shadow; very much as an observer on the deck of a vessel when losing the sight of the hull of another vessel ten miles off, by reason of the interposed convexity of the ocean, stands in the *optical* shadow of the earth. In both cases if the conditions favor, the boundary of the shadow may be re-crossed by ascending from the deck to the mast-head, and the sight or the sound-beam thus regained.



3.—Compound Wind.

Fig. 3 represents the disturbing effect of a lower contrary wind with an opposite wind above. In this case the principal result will be a depression of the sound-beam as in fig. 1, but more strongly marked, as the differences of motion as we ascend will be more rapid. Attending this action, however, there will probably be some lagging of the lower stratum of the adverse wind by reason of the surface friction; the tendency of which will be to slightly distort the lower sound radiations, by giving them a reverse or serpentine curvature. The upper rays of sound would probably have only a single declining curvature, similar to that shown in fig. 1.

One result of this condition of the *locus* of the *normals* (to use a mathematical phrase) would be to make the sound less audible (or possibly sometimes inaudible) at a point (as at *t*) midway between the two stations. This hypothetical case of compound refraction would appear to offer a plausible explanation, not only of the paradox of a nearer trumpet-sound being diminished in power by the wind which increased the effect of a more distant whistle, but also of the puzzling "belt" of inaudibility previously noticed. Duane [D], and Henry [8].

Numerous other cases might be represented by diagrams, as of a sound being hindered or tilted upward by a concurrent wind of unequal velocity, or downward by an opposing wind of similar character, and of the various permutations of differing currents in oblique directions; to which might be added various resultants of unequal motion producing *lateral* refraction, but this is unnecessary. Enough has been said, it is hoped, to clear from popular misapprehension, the admirable hypothesis of Professor Stokes, raised by the equally admirable investigations of Professor Henry, to the rank of a "theory;" and to show that it has a real and demonstrated basis, or in other words that it is a *vera causa*. The question of its sufficiency lies entirely within the grasp of mathematical discussion; but a long series of accurate and comprehensive observations will yet be required to discover its full compass of practical result, and to determine its precise limit of capacity in subjugating the "abnormal phenomena" of sound.

ART. VIII.—*Studies on Magnetic Distribution*; by HENRY A. ROWLAND, of the Johns Hopkins University, Baltimore.

(Continued from page 29.)

VI.

M. JAMIN, in his recent experiments on magnetic distribution, has obtained some very interesting results, although I have shown his method to be very defective. In his experiments on iron bars magnetized at one end, he finds the formula ε^{rL} to apply to long ones as I have done. Now it might be argued that as the two methods *apparently* give the same result, they must be equally correct. But let us assume that the attraction of his piece of soft iron F varied as some unknown power n of the surface-density δ. Then we find

$$F=C\varepsilon^{nrL},$$

which shows that the attractive force or any power of that force can be represented by a logarithmic curve, though not by the same one. Hence the error introduced by M. Jamin's method is insidious and not easily detected, though it is none the less hurtful and misleading, but rather the more so.

However, his results with respect to what he calls the normal magnet* are to some extent independent of these errors; and we may now consider them.

Thus, in explaining the effect of placing hardened steel

* "On the Theory of Normal magnets," *Comptes Rendus*, March 31, 1873, translated in Phil. Mag., June, 1873.

plates on one another, he says: "Quand on superpose deux lames aimantées pareilles, les courbes qui représentent les valeurs de F (the attractive force on the piece of soft iron) s'elévent, parce que le magnétisme quitte les faces que l'on met en contact pour réfugier sur les parties extérieures. En même temps, les deux courbes se rapprochent l'une de l'autre et du milieu de l'aimant. Cet effet augmente avec une troisième lame et avec une quatriéme. Finalement les deux courbes se joignent en milieu."

In applying the formula to this case of a compound magnet, we have only to remark that when the bars lie closely together, they are theoretically the same as a solid magnet of the same section, but are practically found to be stronger, because thin bars can be tempered more uniformly hard than thick ones. The addition of the bars to each other is similar to an increase in the area of the rod, and should produce nearly the same effect on a rod of rectangular section as the increase of diameter in a rod of circular section. Now the quantity $p=\frac{rd}{2}$ is nearly constant in these rods for the same quality of steel, whence r decreases as d increases; and this in equation (17) shows that as the diameter is increased, the length being constant, the curves become less and less steep until they finally become straight lines. This is exactly the meaning of M. Jamin's remark.

Where the ratio of the diameter to the length is small, the curves of distribution are *apparently* separated from each other, and are given by the equation

$$\lambda=\frac{\mathfrak{H}}{4\pi\sqrt{RR'}}\varepsilon^{-rx}, \quad . \quad . \quad . \quad . \qquad (18)$$

which is not dependent on the length of the rod. This is exactly the result found by Coulomb (Biot's Physique, vol. iii, pp. 74, 75.) M. Jamin has also remarked this. As he increases the number of plates, he states that the curves approach each other and finally unite; this he calls the "normal magnet;" and he supposes it to be the magnet of greatest power in proportion to its weight. "From this moment," says he, "the combination is at its maximum." The normal magnet as thus defined is very indefinite, as M. Jamin himself admits.

By our equations we can find the condition for a maximum, and can give the greatest values to the following, supposing the weight of the bar to be a fixed quantity in the first three.

1st. The magnetic moment.

2d. The attractive force at the end.

3d. The total number of lines of magnetic force passing from the bar.

4th. The magnetic moment, the length being constant and the diameter variable.

Either of these may be considered as a measure of the power of the bar according to the view we take. The magnetic moment of a bar is easily found to be

$$M=\frac{\mathfrak{H}}{4\pi r^2 R'}\left\{\frac{b}{2}-\frac{1}{r}\frac{1-\varepsilon^{-rb}}{1+\varepsilon^{-rb}}\right\}; \quad . \quad . \quad (19)$$

and if γ is the weight of a unit of volume of the steel and W is the weight of the magnet, we have finally

$$M=\frac{\mathfrak{H}}{4\pi R'C^2}\left\{\frac{1}{2}-\frac{1}{Cb^{\frac{3}{2}}}\frac{\varepsilon^{Cb^{\frac{3}{2}}}-1}{\varepsilon^{Cb^{\frac{3}{2}}}+1}\right\}, \quad . \quad (20)$$

where $C=\frac{r}{\sqrt{b}}=p\sqrt{\frac{\pi\gamma}{W}}$.

This only attains a maximum when $\frac{b}{d}=\infty$, or the rod is infinitely long compared with its diameter.

The second case is rather indefinite, seeing that it will depend upon whether the body attracted is large or small. When it is small, we require to make the surface-density a maximum, the weight being constant. We find

$$\delta_0=\frac{\mathfrak{H}}{\gamma\pi^2 R'p}\frac{\varepsilon^{Cb^{\frac{3}{2}}}-1}{\varepsilon^{Cb^{\frac{3}{2}}}+1}, \quad . \quad . \quad . \quad (21)$$

which attains a maximum as before when $\frac{b}{d}=\infty$. When the attracted body is large, the attraction will depend more nearly upon the linear density

$$\lambda_0=\frac{\mathfrak{H}}{4C\pi R'\sqrt{b}}\frac{\varepsilon^{Cb^{\frac{3}{2}}}-1}{\varepsilon^{Cb^{\frac{3}{2}}}+1}, \quad . \quad . \quad . \quad (22)$$

which is a maximum when $\frac{b}{d}=\frac{1\cdot 42}{p}$.

For the third case we have the value of Q″ at the center of the bar from equation (6),

$$Q''=\frac{\mathfrak{H}}{2C^2R'b}\frac{(\varepsilon^{\frac{1}{2}Cb^{\frac{3}{2}}}-1)^2}{\varepsilon^{Cb^{\frac{3}{2}}}+1}. \quad . \quad . \quad . \quad (23)$$

The condition for a maximum gives in this case

$$\frac{b}{d}=\frac{1\cdot 65}{p}.$$

For the last case in which the magnetic moment for a given length is to be made a maximum, we find

$$\frac{b}{d}=\frac{\cdot 1}{p}.$$

This last result is useful in preparing magnets for determining the intensity of the earth's magnetism, and shows that the magnets should be made short, thick, and hard for the best effect.*

But for all ordinary purposes the results for the second and third cases seem most important, and lead to nearly the same result; and taking the mean we find for the maximum magnet

$$\frac{b}{d}=\frac{1\cdot5}{p}. \quad . \quad . \quad . \quad . \quad . \qquad (24)$$

We see from all our results that the ratio of the length of a magnet to its diameter should vary inversely as the constant p. This constant increases with the hardness of the steel, and hence the harder the steel the shorter we can make our magnets. It would seem from this that the temper of a steel magnet should not be drawn at all, but the hardest steel used, or at least that in which p was greatest. The only disadvantage in using very hard steel seems to be the difficulty in imparting the magnetism at first, and this may have led to the practice of drawing the temper; but now when we have such powerful electromagnets, it seems as if magnets might be made shorter, thicker and harder, than is the custom. With the relative dimensions of magnets now used, however, hardening might be of little value.

We can also see from all these facts, that if we make a compound magnet of hardened steel plates there will be an advantage in placing more of them together, thus making a thicker magnet than when they are softer. We also observe that as we pile them up the distribution changes in just the way indicated by M. Jamin, the curve becoming less and less steep.

Substituting in the formula the value of p which we have found for Stub's steel not hardened, but still so hard as to rapidly dull a file, we find the best ratio of length to diameter to be 33·8, and for the same steel hardened about 17, though this last is only a rough approximation. This gives what M. Jamin has called the normal magnet. The ratio should be less for a U-magnet than for a straight one.

For all magnets of the same kind of steel in which the ratio of length to diameter is constant the relative distribution is the same; and this is not only true for our approximate formula, but would be found so for the exact one.

Thus for the "normal magnet" the distribution becomes

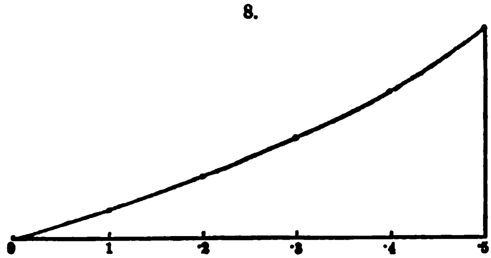
$$\lambda=C(\varepsilon^{3\frac{x}{b}}-\varepsilon^{-3\frac{x}{b}}),$$

where C is a constant, and x is measured from the center. The distribution will then be as follows:

* Weber recommends square bars eight times as long as they are broad, and tempered very hard. (Taylor's Scientific Memoirs, vol. ii, p. 86.)

$\frac{x}{b}=$	0	·1	·2	·3	·4	·5
$\frac{\lambda}{C}=$	0	·609	1·27	2·05	3·02	4·26

8.



Distribution on "normal magnet."

This distribution is not the same as that given by M. Jamin; but as his method is so defective, and his "normal magnet" so indefinite, the agreement is sufficiently near.

The surface-density at any point of a magnet is

$$\delta = \frac{\mathfrak{H}}{8\pi^2 p R'} \frac{\varepsilon^{2p\frac{x}{d}} - \varepsilon^{-2p\frac{x}{d}}}{\varepsilon^{p\frac{b}{d}} - \varepsilon^{-p\frac{b}{d}}}, \quad . \quad . \quad . \quad (25)$$

which, for the same kind of steel, is dependent only on $\frac{x}{d}$ and $\frac{b}{d}$. Hence in two similar magnets the surface-density is the same at similar points, the linear density is proportional to the linear dimensions, the surface integral of magnetic induction over half the magnet or across the section is proportional to the surface dimensions of the magnets, and the magnetic moments to the volumes of the magnets. The forces at similar points with regard to the two magnets will then be the same. All these remarks apply to soft iron under induction providing the inducing force is the same, and hence include Sir William Thomson's well-known law with regard to similar electromagnets; and *they are accurately true notwithstanding the approximate nature of the formula from which they have here been deduced.*

Our theory gives us the means of determining what effect the boring of a hole through the center of a magnet would have. In this case R′ is not much affected, but R is increased. Where the magnet is used merely to affect a compass-needle, we should then see that the hole through the center has little effect where the magnet is short and thick; but where *it is long, the attraction on the compass-needle is much diminished.* Where the magnet is of the U-form, and is to be used for sustaining weights, the *practice is detrimental, and the sustaining-power is diminished*

in the same proportion as the sectional area of the magnet. The only case that I know of where the hole through the center is an advantage, is that of the deflecting magnets for determining the intensity of the earth's magnetism, which may be thus made lighter without much diminishing their magnetic moment.

In conclusion, let me express my regret at the imperfection of the theory given in this paper; for although the equations are more general than any yet given, yet still they rest upon two quite incorrect hypotheses; and so, although we have found these formulas of great use in pursuing our studies on magnetic distribution, yet much remains to be done. A nearer approximation to the true distribution could readily be obtained, but the results would, without doubt, be very complicated and would not repay us for the trouble.

In this paper, as well as in all the others which I have published on magnetic subjects, my object has been not only to bring forth new results, but also to illustrate Faraday's method of lines of magnetic force and to show how readily calculations may be made on this system. For this reason many points have been developed at greater length than would otherwise be desirable.

ART. IX.—*On rifts of Ice in the rocks near the summit of Mt. McClellan, Colorado, and on the different Limits of Vegetation on adjoining summits in the Territory;* by EDWARD L. BERTHOUD.

THE silver mines of Argentine District, a mining center about eight miles southwest from Georgetown, are located on the north slope of a high peak named McClellan Mountain, which forms a very prominent point of the main central range, and immediately facing a precipice fully 1500 feet high, the majestic mass of Gray's Peak; while 1½ miles south is Argentine Pass, 13,100 feet in height.

This mountain, 13,430 feet* above the sea, is intersected in a northeast and southwest direction by a system of mineral veins, containing silver in large quantity with a little gold. The veins seem generally to be nearly vertical, and occur at elevations varying from 12,300 feet to 13,400 feet. Three of them have been extensively mined, and two, the International and Belmont, have been developed and worked since 1867–68 with success, and with fair paying results; but with probably at a greater average cost per ton of mineral mined than any other similar mines in Northern Colorado. The Centennial Lode, the third mine examined, is now being well developed by its owners, who

* Vide Gardner, in Hayden's Report, 1873–74.

are working into the vein horizontally by excavating a drift. The ores found in these mines are galena rich in silver, decomposed quartz and honey-combed quartz, with sulphurets of silver, and some decomposed iron pyrites and a little carbonate of lead, with occasional small patches of sphalenite.

I have been thus particular in the description of these mines, merely to give a good general idea of their value and location. In a personal and critical examination of them, during a recent visit to the region, a peculiar feature was observed which excited much surprise.

The discovery-drift of the Centennial Lode runs into McClellan Mountain at an altitude above 13,100 feet, on a course southwest, at about 30 feet from the entrance of the tunnel. Intercalated in the vein, I found three or four well defined veins of solid ice, parallel with the bedding of the rock, and filling all its thinner side cracks and fissures; in fact, after further examination I found that the frozen stratum, and the congealed, hard earth, rock and gravel, began only a few feet below the accumulated rock and debris of the mountain slope, and continued as far as the excavation reached, some forty feet in depth.

From the Centennial Lode I went westward about 300 feet, and examined the drift that has been excavated into the mountain some 500 feet, upon the vein of the International Lode. Here there is repeated the same frozen substratum and the same rift or veins of ice in the country rock and in the vein. I went into the tunnel about 100 feet and found this glacial condition still existed; and the owner of the mine assured me that the ice and frozen rock continued all the way to the end of the tunnel and caused a good deal of extra expense in mining the ore.

The course of the "International Lode" is southwest, and its drift is about 50 feet in vertical elevation above the drift of the Centennial Lode.

The next "Lode" examined was the Belmont Lode, west and nearly parallel to the International. This mine is exploited by a system of horizontal galleries one above the other to the summit of the mountain, at 13,400 feet elevation. In the lower galleries the same frozen icy condition prevails as at the first two veins. But the summit drift, which was at the date of my visit about 60 feet long, does not show veins of ice in the wall-rock of the veins; this is probably due not only to the greater narrowness of the summit, here scarcely 200 feet where pierced by the tunnel, but also to the influence of wind and sun upon its western seamed and riven surface, and to its more perfect drainage and exposure.

This is certainly a singular phenomenon, when we consider that across the narrow valley north of McClellan Mt., not over

three-fourths of a mile distant and upon another high peak, the limit of tree growth exceeds 12,400 feet elevation on the south slope of that peak. Here can be seen *Pinus aristata*, some of the trees two feet in diameter and thirty feet high that retain their hold, and slowly increase in size, thus maintaining themselves in respectable numbers in spite of furious gales of snow and wind, and an extreme Arctic cold.

In Miscellaneous Publications, No. 1, U. S. Geological Survey of the Territories, which was published last year, under the direction of Prof. F. V. Hayden, the line of tree growth is given by Mr. J. T. Gardner in his report, as from 11,000 feet to 11,900 feet, between latitudes 39° and 40°. We believe this to be correct, and a fair general average. In Argentine District, which comprises McClellan Mountain, we have a very notable departure from this limit of from 500 to 1400 feet in elevation, and also about 1300 feet above timber line on Gray's Peak, three to four miles southwest, as given by Mr. Gardner. At the Equator and in the Torrid zone the limit of the growth of Pines is generally placed at 12,800 feet above the sea; how is it that, in lat. 39° 33′ N., the limit of the growth of Pines has receded only 400 feet?

In McClellan Mountain and in Argentine District there are two antagonistic phenomena in immediate proximity; on one side of the valley, a mountain slope facing northeast, well grassed, totally devoid of shrubs and trees, where soil and rocky debris are underlain by a perpetual icy coat of hundreds of feet in depth, supporting on its surface a growth of plants strictly Alpine and Arctic, and abounding with Ptarmigan, *Lagopus leucurus*, and the tailless, earless marmot; and where on the 2d October, 1875, I found the following plants yet in bloom: *Sedum stenopetalum*, *Potentilla norvegica*, *P. fruticosa*, *Sibbaldia procumbens*, *Astragalus alpinus*, *Silene acaulis*, *Draba aurea*, *Phleum alpinum*, *Primula Parryi*, *Gentiana*, *Heuchera*, *Castilleia pallida*, *Ranunculus nivalis*, *Pedicularis*, *Cardamine and Crepis*, while less than half mile distant, on the opposite slope of the vale, *Pinus aristata* of large size and a profuse growth of birches, willows, grasses and Arbutus, with flowing springs and small ponds, diversify its southwestern slope.

It has been suggested* that the frozen soil and rock of some mines examined by him, northwest from McClellan Mountain, on the west slope, have been thus left ice bound since the Glacial period; and that they thus retain their former ice-bound condition, from the excessive altitude of the mines there explored.

This may be the case, but it seems doubtful. There are in Colorado many mines at altitudes very nearly as high as the highest on McClellan Mountain, yet none have been exploited to the

* R. Weiser, in this Journal, III, viii, 477, 1874.

depth of from 100 to 500 feet in solid frozen soil and ice ribs. I am inclined to believe that the glacial condition of McClellan Mountain is due to local causes. Prominent among these would be the loose nature of the soil and deep rocky debris of the mountain, and the slow percolation of water exposed to excessive evaporation that is promoted and quickened by continued gales from the north and northwest that strike against the precipitous face of the mountain range in that direction. The opposite slope, on the contrary, which shows the abnormally high timber line, faces a Pass (Argentine Pass) 13,100 feet in height, which gives a way perfectly unobstructed for south-southwest winds. These prevail frequently in winter and spring, and are invariably temperate or even warm, and thus to their influence may be due the milder and more propitious character of this locality. In Colorado Territory it has been remarked that in our mountains, even in January, a southwest wind is invariably genial and warm; in two hours I have known a southwest wind to raise the thermometer from 13° below zero to 47° above. This abrupt change, however, is disastrous to tree growth, and destroys the quaking Asp, Cedar, and even Pines in more exposed localities; while the Cherry, Box Elder and the bitter Cottonwood (*Populus angulata*) have perished in the ensuing spring in our lower valleys and on the foot-hills.

I have presented this subject in order to secure for it further elucidation and discussion. The facts are of no little interest, since they conflict with accepted views as to the limits of growth of plant, and the influence of altitude on climate.

ART. X.—*On a New Form of Lantern Galvanometer;* by FRANCIS E. NIPHER, Professor of Physics in Washington University.*

IN the September number of this Journal, Prof. Barker has described a lantern galvanometer, which appears to possess many advantages over any heretofore described, and which is evidently a valuable addition to the apparatus of the public lecturer.

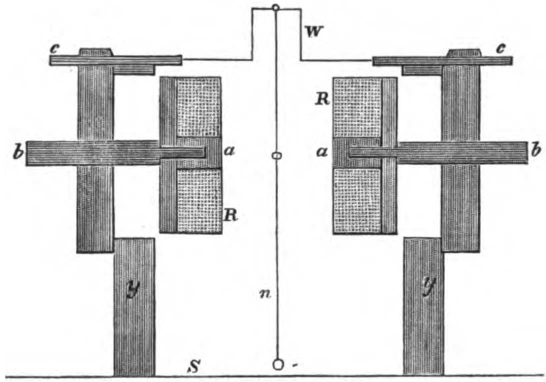
While meditating the construction of this instrument, the galvanometer now to be described was devised. A vertical section is shown in Fig. 1.

A square box (Y, Y), open at the top and bottom, is pierced on opposite sides to admit the wooden rods (*b*). To the inner extremities of these rods are attached coils (R), of covered cop-

* Read before the St. Louis Academy of Science, Oct. 18, 1875.

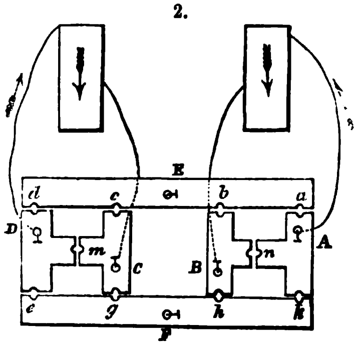
per wire, No. 14, wound upon cylinders of wood (a).* Wooden rods (c), clamped so as to move with gentle friction, bear a wire (w), from which an astatic system of needles is suspended by means of a silk fiber. The upper needle is midway between

1.



the centers of the two coils. The lower needle plays over a scale (s) photographed on glass, beneath which is the horizontal condensing lens of the vertical lantern. The needles are ordinary sewing needles, and are each 1·5 inches in length.† Each coil is composed of 34·7 meters of wire, the resistance of which is 0·444 ohms. Each coil should have the same number of windings, and the same resistance. This is easily effected by care in winding. By sliding the rods (b) in or out, the distance between the coils may be varied from 2 cm. to 10 cm., the image of the lower needle being in all cases perfectly distinct. In this way the instrument is adjusted to currents of any strength. Scales cut in the rods (b) serve to regulate the distances.

2.



On the outside of the box are six plates of brass, whose form and arrangement are shown in fig. 2. The extremities of the coils are connected with the four plates A, B, C, D. This connection may be made by means of binding-screws on the inside of the box, in which case the coils may be replaced with ease by others of greater or less resistance. The plates are put in metallic contact by means of

*** For Duboscq's lantern, the coils must be placed lower than here represented.**

† The lower needle may be replaced by a bristle from a painter's brush, or some other light pointer, the upper one being damped by magnets as recommended by Mayer.

brass plugs, inserted at *a*, *b*, *c*, *d*, *e*, *g*, *h*, *k*. Putting plugs at *h* and *e*, and connecting the poles of a galvanic cup at the binding-screws A and C, and the current runs successively through the two coils R, each causing deflection in the same direction. Let R represent the resistance of one coil of the galvanometer, then the resistance of the galvanometer will be 2R. This arrangement is used in working with ordinary galvanic currents.

If instead of the former connections, plugs be put at *a*, *d*, *g*, and *h*, the wires from the source of electricity being connected at E and F, then the galvanometer resistance becomes $\frac{1}{2}$R. This arrangement is to be used with circuits of small resistance, such as thermo-currents. For this kind of work the instrument is thoroughly adapted.

This instrument can also be used as a differential galvanometer. To do this, put the positive pole of the battery at E. Plug *a* and *c*. Divide the negative wire into two equal branches which are to be connected at B and D. The circuit being thus closed, the needle evidently remains at zero. Introducing any wire the resistance of which is to be determined, into one branch, bring the needle to zero again by introducing known resistances into the other, and the unknown resistance is readily determined. In measuring fractions of an ohm, a rheochord is, all things considered, the best. The contacts are good, and an audience obtains a better idea of what is meant by electrical resistance than when a resistance box alone is used. Using platinum wire weighing 7·37 grams per meter, the resistance of which is one ohm to 192·9 cm. of wire (which is 96·45 cm. on the instrument scale), and thousandths of an ohm can be measured direct.

If ground connections are made the negative pole of the battery is sent to ground direct, and the branches of the current from B and D are sent to ground through the unknown resistance and the resistance box respectively.

Shunts may be introduced into either of the half circuits. This may be done by introducing coils of resistance $\frac{1}{9}$R or $\frac{1}{99}$R, between the binding screws A, B or C, D. These wires may also be wound upon metallic plugs, which have been split lengthwise, the parts being insulated and each being connected with one extremity of the wire. Permanent shunts may be introduced by connecting one extremity with plates A or D, the other extremity being attached to an insulated plate, to be put in contact with B or C by means of a solid metallic plug. These shunts are used in Latimer Clark's differential galvanometer, and their use in measuring resistance is too well known to need further explanation.

The advantages possessed by this galvanometer are:

1. It is easily adjusted to any vertical lantern, from which it can be removed in a moment if desired.

2. The distance between the deflecting coils being readily varied, it can be adjusted to currents of various intensity.

3 The resistance of the galvanometer is quickly varied from one-half, to twice the resistance of one of the galvanometer coils.

4. The coils may be replaced by others when desired.

5. It can instantly be converted into a differential galvanometer and used in measuring resistance.

6. It can be constructed in any work-shop at a very small expense.

St. Louis, Oct. 25, 1875.

ART. XI.—*On a new occurrence of Tartronic Acid, with some remarks on the Molecular Structure of Glyceric Acid;* by SAMUEL P. SADTLER.

(Read before the American Philosophical Society, September 17, 1875.)

IN the Propyl series, nine normally formed acids are possible, besides several isomeric unsymmetrically formed ones. They are:—

I.	IV.	VII.
$C_3H_6O_2$	$C_3H_6O_3$	$C_3H_4O_4$
CH_3	$CH_2.OH$	$CO.OH$
CH_2	CH_2	CH_2
$CO.OH$	$CO.OH$	$CO.OH$
II.	**V.**	**VIII.**
$C_3H_6O_3$	$C_3H_6O_4$	$C_3H_4O_5$
CH_3	$CH_2.OH$	$CO.OH$
$CH.OH$	$CH.OH$	$CH.OH$
$CO.OH$	$CO.OH$	$CO.OH$
III.	**VI.**	**IX.**
$C_3H_4O_3$	$C_3H_4O_4$	$C_3H_2O_5$
CH_3	$CH_2.OH$	$CO.OH$
CO	CO	CO
$CO.OH$	$CO.OH$	$CO.OH$,

and the following are the acids considered as having the molecular structure just given:—

I, propionic acid; II, lactic acid (of fermentation); III, pyruvic or pyro-racemic acid; IV, ethylene lactic acid; V, glyceric acid; VI, carbacetoxylic acid; VII, malonic acid; VIII, tartronic acid; IX, mesoxalic acid.

In one or two of these cases, however, there is still a difference of opinion as to whether the acid named is the one possessing the normal molecular structure given above, or is only an isomer of it, having its carbon atoms differently united. Notably with glyceric acid is this yet an open question. Some results lately obtained in the course of a study of this acid appear to me to be of value for the solution of this question.

The other view of the molecular structure of glyceric acid makes it unsymmetrical, two of the carbon atoms being doubly united. The formula given is

$$\begin{array}{ll} & CH_2.OH \\ & \;| \\ / & C.OH \\ O & \;| \\ \backslash & CH.OH. \end{array}$$

As will be seen, this formula does not contain the carboxyl group, hitherto supposed to be the inevitable characteristic of an organic acid. The author of this theory is Prof. Wislicenus, of Würzburg, and the following are the reasons given in support of it. If lactic acid be acted upon with hydrogen iodide, α iodo-propionic acid is formed, according to the following reaction:

$$\begin{array}{l} CH_3 \\ | \\ CH.OH + HI = \\ | \\ C.OOH \end{array} \begin{array}{l} CH_3 \\ | \\ CH.I \quad + H.OH \\ | \\ CO.OH. \end{array}$$

This when heated to 150° with strong HI is changed into propionic acid. If, on the other hand, glyceric acid be acted upon with hydrogen iodide, β iodo-propionic acid is formed. If this had the formula

$$\begin{array}{l} CH_2I \\ | \\ CH_2 \\ | \\ CO.OH, \end{array}$$

on treatment with moist silver oxide, it would pass into ethylene lactic acid. It does not, however, do this, but a new acid isomeric with ethylene lactic acid is formed—hydracrylic—

$$\begin{array}{ll} & CH_2.OH \\ & \;| \\ / & CH \\ O & \;| \\ \backslash & CH.OH. \end{array}$$

That the molecular structure of this acid is essentially different from that of ethylene lactic acid is proved by the oxydation products of the two. Ethylene lactic acid yields malonic acid, while hydracrylic does not yield a trace of this, breaking up into glycolic and oxalic acids and carbonic dioxide. Moreover, hydracrylic acid on heating yields acrylic acid, a derivative of allyl alcohol, instead of the lactid yielded by the lactic acids.

Prof. Wislicenus, however, frankly gives one experiment made by himself, the result of which tends the other way. He reduced the β iodo-propionic acid by sodium amalgam and obtained what appeared to be the normal propionic acid, showing the regular molecular structure.

In favor, moreover, of the normal structure for the molecule of glyceric acid is the formation of pyruvic or pyroracemic acid.

$$\begin{array}{l} CH_3 \\ | \\ CO \\ | \\ CO.OH \end{array}$$

from glyceric acid upon heating this to 140°, explained by the following reaction:

$$\begin{array}{l} CH_2.OH \\ | \\ CH.OH \\ | \\ CO.OH \end{array} - H.OH = \begin{array}{l} CH_3 \\ | \\ CO \\ | \\ CO.OH. \end{array}$$

The structure of this pyruvic acid is known from the fact that acted upon by nascent hydrogen it gives normal lactic acid.

A strong additional argument would be had, if we could show a connection between glyceric acid,

$$\begin{array}{l} CH_2.OH \\ | \\ CH.OH \\ | \\ CO.OH \end{array}$$

and tartronic acid,

$$\begin{array}{l} CO.OH \\ | \\ CH.OH \\ | \\ CO.OH. \end{array}$$

Hitherto tartronic acid had not been formed from glyceric acid, but only in an indirect way, by the spontaneous decomposition of nitro-tartaric acid, according to the following reaction:

$$\begin{array}{l} CO.OH \\ | \\ CH.O(NO_2) \\ | \\ CH.O(NO_2) \\ | \\ CO.OH \end{array} = \begin{array}{l} CO.OH \\ | \\ CH.OH \\ | \\ CO.OH \end{array} + N_2O_3 + CO_2.$$

However this mode of formation was interesting as tending to show its symmetry of structure. For that matter a dibasic, triatomic acid could hardly exist, except by the assumption of two carboxyl groups.

I have been fortunate enough to find tartronic acid associated with glyceric acid in the oxydation products of glycerine. The preparation of the two acids was as follows: One part by weight of glycerine is mixed with one part of water, and to the mixture is added, by means of a long funnel tube reaching to the bottom of the cylinder, about one and a quarter parts of

red fuming nitric acid. After allowing them to rest until all gas evolution has ceased (which usually takes some six days), the solution is evaporated down at a gentle heat until the fumes of nitric acid are no longer perceptible. It is then very thick and syrupy. It is now diluted with water, and plumbic carbonate is added in excess. The oxalate and undissolved carbonate are filtered off, and the solution slightly concentrated and allowed to crystallize. The glycerate of lead deposits in thick crystalline crusts. These are separated from the mother-liquor, dissolved, and the lead precipitated out from the solution by sulphuretted hydrogen.

The colorless or light straw-colored filtrate is somewhat concentrated, and calcic carbonate is added to neutralization. The solution is filtered, if necessary, and to the filtrate is added 95 per cent alcohol. The calcium salts present are all precipitated, in greater part at once, and completely on standing twelve hours.

If the solution had been very concentrated the calcium salt is precipitated in a granular condition. If, on the other hand, it was more dilute, the salt only separates gradually, and has a beautiful micaceous and scaly appearance.

I had at first considered this precipitate to be pure calcium glycerate, but found on dissolving it in water, in order to free it from the lime and obtain the glyceric acid, that while the greater portion dissolved readily in warm water, a considerable portion, although not more than one-tenth of the whole amount, remained and dissolved only on continued boiling. This, when filtered off and washed in cold water, appeared as a dull white, almost impalpable powder, contrasting in appearance with the crystalline glycerate.

It was dried carefully at 100° until constant weight was obtained.

Calcium determinations were first made. Weighed portions were ignited in a platinum crucible once or twice with excess of concentrated sulphuric acid until the weight remained constant.

·5755 grms. salt yielded ·4925 grms. $CaSO_4$ equal to 25·22 per cent Ca.

·1759 grms. salt yielded ·1505 grms. $CaSO_4$ equal to 25·16 per cent Ca.

The theoretical per cent of calcium in calcium tartronate is 25·32, while in calcium glycerate, allowing for two molecules of water of crystallization, it is 13·99.

I had analyzed the micaceous preparation of calcium glycerate about the same time, and had gotten in two determinations, 14·03, 14·07 per cent of calcium respectively. The difference was so great that I could not understand it. On

reckoning up the molecular weight, however, assuming one atom of calcium to be present, I got 159. The molecular weight of calcium tartronate is 158. Being dibasic, the molecular weight of the calcium compound is of course much less than the weight of the calcium compound of glyceric acid, a monobasic acid.

I endeavored twice to make a combustion of the salt in order to get the per cent of hydrogen and carbon. Each time calcium carbonate remained undecomposed at the heat of the combustion. I therefore gave them up.

I then took the remainder of my salt, grown rather small, to my great regret, and neutralizing the lime with oxalic acid, obtained the free acid. This, on concentration, deposited out crystals. On examination with a lens they were seen to be of tabular form, well agreeing with the appearance of tartronic acid obtained from nitro-tartaric acid. A combustion was made of these, and here, unfortunately, an accident to the potash bulbs lost me the carbon determination. The hydrogen determination, however, is given.

·4348 grms. salt yielded 13·23 grms. H_2O equal to 3·38 per cent hydrogen.

The theoretical per cent of hydrogen in $C_3H_4O_5$ is 3·33.

An important test that I wished to make but was compelled to forego for the time, was to act upon this tartronic acid with hydrogen iodide. Were its structure symmetrical, it should yield α iodo-malonic acid, which by further treatment with HI or with reducing agents would yield malonic acid.

Wishing to obtain larger quantities of the tartronic acid for further examination, I have since oxidized another portion of glycerine and treated the products in the same way. This time I got no tartronic acid whatever, at least only a trace of calcium salt remained undissolved on heating with water. Evidently here the oxidation had proceeded somewhat differently as no tartronic acid formed. This result is not surprising on reflection, as the oxidation by nitric acid is not capable of much control, and a product once formed is liable to be still further oxidized. Thus glyceric and tartronic acids are both liable to be oxidized into oxalic acid, which always forms in considerable though varying quantity. Indeed the oxidation of glycerine by nitric acid is now known to yield a variety of products, of which, however, no doubt some are secondary ones.

Thus Heintz* has proved that racemic, formic, glycolic and glyoxalic acids are all found associated with the glyceric and oxalic acids in this product.

The tartronic acid just found, therefore, is only one of sev-

* Ann. der Ch. und Ph., clii, p. 325.

eral smaller side-products. The known symmetry of structure of the molecules of all these side products, however, certainly argues in favor of a similar symmetry in the glyceric acid molecule.

There is one way of reconciling these two views of the structure of glyceric acid, and that is the assumption of the existence of two isomeric acids, of which one is normal and the other an unsymmetrical acid.

Some results that I have just obtained in purifying the calcium glycerate seem, indeed, to point this way. Should the unsymmetrical glyceric acid preponderate in this mixture, Wislicenus' reactions with hydrogen iodide are readily understood. Another fact, which should not be lost sight of, is that in the decomposition of β iodo-propionic acid by moist silver oxide, Wislicenus* obtained not hydracrylic acid alone, but three other products accompanying it, so that the decomposition was not so simple

I am now engaged upon a study of this question, and hope to be able to give more information upon it in a short time.

Art. XII.—*Note on the "Chloritic formation" on the western border of the New Haven Region;* by James D. Dana.

The rocks of the hilly region west of the New Haven plain are, for nine miles westward, metamorphic slates, and beyond this distance mostly gneiss. Immediately adjoining the region there is what Percival has called a "chloritic formation," the area trending about north-northeast; then on the west of this, with the same trend, (2) a hydromica slate, but little removed from argillite, becoming slightly garnetiferous toward the western limit; next (3) a glossy garnetiferous mica slate, containing some beds of gray semi-crystalline limestone; next (4) at Derby, common gneiss and coarse porphyritic gneiss. These rocks are involved in one system of folds, and are throughout conformable in bedding.

The rock of the "chloritic formation" varies much in texture and composition in passing from the Sound northward. Near Savin Rock, on the Sound, it is a chloritic hydromica slate. The gray and slightly silvery surface is more or less blotched and lined with the olive-green of chlorite, and the rock has in the mass in general a greenish tint. The slaty structure is usually perfect, and yet some layers fail of it. Grains of magnetite are common, and, less so, those of pyrite.

* Ann. der Ch. und Ph., clxvii, p. 41.

This slaty variety of the rock continues with little change for a mile and a half north. Beyond, the massive layers increase in extent. At the deep Derby railroad cut, two miles north of Savin Rock, the massive variety constitutes more than half of the rock exposed in the sections; and it is not all in separate beds; for thick beds that are slaty in one part are in others for many rods massive, and it is impossible to separate the massive from the slaty by any stratigraphical planes.

This massive rock is commonly without a trace of bedding; at the same time, it is variously and extensively jointed, so that it affords only deceptive indications of strike or dip. It varies in color from greenish gray to dark olive-green and blackish gray. Some of it is almost cryptocrystalline; but in general the texture is fine granular. Part of it is porphyritic with small crystals of a whitish feldspar.

Between this Derby cut and "Maltby Park," a mile and three quarters west of north, this massive rock constitutes nearly all the outcrops; and in some places the porphyritic variety is pale greenish gray, from the thickly crowded feldspar crystals.

Over Maltby Park the rock is again slaty and silvery, often with blotches of chlorite—a chloritic hydromica slate—as at Savin Rock; yet with enough of both the ordinary and porphyritic *massive* kinds among the slaty layers to exhibit its close relation to the rocks farther south. The slate occasionally has the chlorite in large lenticular concretions, and now and then is light gray and contains crystals of pyroxene. In some places, especially along seams, it is epidotic. Veins and seams of quartz are numerous. In the slate there are interrupted beds of limestone. Part of the limestone contains serpentine and is a handsome verd-antique marble; and with the serpentine there are often grayish green cleavable pyroxene (sahlite), asbestus and chromic iron.

A mile farther north, or five miles from Savin Rock, (west of Westville), the rock is almost wholly a dark green chlorite slate—the micaceous part absent.

The rocks in the course of the five to six miles are—in recapitulation—commencing at the Sound:

For 1½ miles, chloritic hydromica slate, little of it massive.
1½ to 2½ miles, chloritic hydromica slate, much of it massive.
2½ to 4 miles, massive chloritic rock with little of it slaty.
4 to 4¾ miles, chloritic hydromica slate, very little of the rock massive.
4¾ to 6 miles, mostly dark green chlorite slate.

It is to be noted that throughout the formation the slaty and massive portions are so associated, sometimes as alternating

beds, sometimes as parts of the same beds, that *their common metamorphic origin* cannot be questioned—a point that I have studied for years.

The resemblances of the massive rock to trap was long since noticed by Professor Silliman, who, in a paper on the geology of New Haven and its vicinity, published in 1811 in Bruce's Mineralogical Journal, called it "primitive greenstone." In fact, the similarity in external aspect is so close that hand specimens from some portions of it would without question be pronounced trap—that is, doleryte, diabase, or melaphyre—by the most experienced lithologists.

In 1872, an incomplete analysis of the feldspar in the pale grayish green porphyritic rock, outcropping just south of Maltby Park, was made, by Mr. Edward S. Dana. The amount of silica afforded by the feldspar having been found to be but 45 per cent, the conclusion suggested was that the rock consisted largely of labradorite, and that it was probably essentially identical with part of the trap of the Connecticut valley dikes. In view of the presence of chlorite, I hence regarded the compact rock of the region as a metamorphic diabase; and it is the rock specially referred to under that name in the last edition of my Manual of Geology.

Still, the analysis, besides being incomplete, was not satisfactory because the feldspar crystals, although of the normal hardness, were granular in texture, without good cleavage, suggesting that they might possibly have undergone a partial alteration. On account of Mr. Dana's departure for Europe, he was compelled to leave the investigation he had begun unfinished; and so it has remained until this summer, when it was taken up, at my request, by the skillful analyst connected with the mineralogical department of the Sheffield Scientific School of Yale College, Mr. George W. Hawes. His results prove that the rocks are in fact *metamorphic doleryte*, *metamorphic diabase*, and *metamorphic melaphyre;* the first two, labradorite rocks, and the last an oligoclase variety. To distinguish these metamorphic rocks from the igneous of the same composition, they are named, on my suggestion, *metadoleryte*, *metadiabase*, and *metamelaphyre*. The examples are part of a long series of rock species which have representatives both among igneous (or intrusive) and metamorphic rocks. Other kinds are *dioryte* and *metadioryte*. *syenyte* and *metasyenyte*, *felsyte* and *metafelsyte*, etc.

We have here the important geological fact that labradorite is a prominent constituent of certain metamorphic rocks which have the aspect of much dioryte, and which are probably of Lower Silurian origin.* The labradorite—a lime-and-soda feld-

* On the question of their age I have collected many facts and propose before long to publish.

spar—must have been a result of the metamorphic process. And its formation was probably favored by two conditions in the original mud-beds so changed; (1) the presence of a comparatively small percentage of silica, or not over 50 per cent; and (2) the presence of much disseminated carbonate of lime probably derived mainly from pulverized fossils. The fact that the chloritic formation contains two or more beds of limestone is reason for supposing that the mud elsewhere may have been more or less calcareous. The oligoclase of the metamelaphyre required for its formation only that the mud should contain a little more silica and soda and less lime.

The terms *doleryte* and *diabase* are here retained for the *igneous* rocks which have been so called—*diabase* being applied to the chloritic variety of doleryte.* Some German works on Lithology restrict the term doleryte to dolerytes not older than the Tertiary, and call the other kinds, whether chloritic or not, diabase. But this is giving different names to the same compound; and it is making geological age—a criterion fortunately never considered in the naming of other rocks—override difference of mineral composition.

ART. XIII.—*Contributions from the Sheffield Laboratory of Yale College.* No. XXXVII.—*The Rocks of the "Chloritic formation" on the Western Border of the New Haven region;* by GEORGE W. HAWES.

THE rocks which compose the ridge fronting the New Haven plain on the west, in the town of Woodbridge and Orange, and which have been described in the foregoing article by Professor Dana, bear, as he states, a close resemblance to the trap rocks of the Connecticut Valley. It hence becomes interesting to ascertain whether the similarity is sustained by their chemical composition and mineral constituents.

As in the case of the trap, these rocks are of different kinds. *First*, dark-colored crystalline rocks very similar in color, texture, fracture, and specific gravity, to the undecomposed dolerytes of this region; and *second*, rocks which are more or less green and appear to be chloritic, very closely resembling the diabase. The latter kind has its porphyritic varieties. Besides these there is a *third* kind which contains a higher percentage of silica, and has the composition of melaphyre.

I. *Metadoleryte.*—A specimen collected from an outcrop about a mile south of Maltby Park (on what was formerly Mr.

*** On the origin of this chloritic condition of part of the trap of the Connecticut valley—the part distinguished here as diabase—see this Journal III, vi, 104, 1873; also Mr. G. W. Hawes, ibid., ix, 191, 1875.**

Stoeckel's farm) was selected for analysis. It was crystalline-granular in texture; and it would be hard to detect by the eye any difference between it and many kinds of doleryte which are found in this region. The analysis shows that in chemical composition also it is very nearly the same. An analysis of a specimen of true igneous doleryte, from the trap ridge called West Rock, in New Haven, is placed beside it for comparison.

METADOLERYTE, FROM STOECKEL'S FARM.

	I.	II.	Mean.		Doleryte, from West Rock.
Silica	50·40	50·32	50·36		51·78
Alumina	14·43	14·71	14·57		14·20
Ferric oxide	2·48	2·47	2·48		3·59
Ferrous oxide	8·28	8·35	8·31		8·25
Manganous oxide	·43	.49	·46		·44
Lime	11·15	11·11	11·13		10·70
Magnesia	7·65	7·59	7·62		7·63
Soda	3·01	3·08	3·04		2·14
Potash	·43	·44	·44		·39
Titanic acid	1·65	1·74	1·70		
Chromic oxide	*tr.*	*tr.*	*tr.*	P_2O_5	·14
Ignition	·74	·83	·78		·63
	100·65	101·13	100·89		99·89
Specific gravity			3·04		3·03

The close resemblance between the igneous and the metamorphic rock will be noticed; they differ from one another less than do the different varieties of doleryte. Moreover, observations made upon thin sections indicate that the rock is composed of pyroxene, a triclinic feldspar, and a black opaque mineral which the analysis shows to be titanic iron. The pyroxene is a dark-green variety, but clear and undecomposed. If we assume that the pyroxene of this rock is of the same composition as that of the New Haven dolerytes,* the magnesia indicates that it contains 55 per cent of this ingredient, which being subtracted along with 3 per cent of titanic iron, leaves 41 per cent of a mineral, the oxygen ratio of which is very near to 1 : 3 : 6—proof that the feldspar is labradorite. Hence, the physical appearance, the chemical composition, and the proportion between the mineral constituents all show a very close resemblance to doleryte. The name of *metadoleryte* seems therefore to be particularly appropriate for this rock.

2. *Metadiabase.*—The chloritic variety, which has been referred to, resembles diabase in appearance as closely as the preceding kind does doleryte. There are, however, wider limits of variation in texture and in the proportion between the mineral constituents than is noticed in diabase; for the rock is sometimes uniformly crystalline, and sometimes coarsely

* See this Journal, III, ix, page 187.

porphyritic. As would be supposed, there are no amygdaloidal cavities or geodes either in the mass or in microscopic sections. The analysis was made upon a specimen collected at the Derby railroad cut where there is a fine display of these rocks. The specimen was uniform in texture and of a light-green color.

METADIABASE, FROM THE DERBY RAILROAD CUT.

	I.	I.	Mean.
Silica	48·25	48·15	48·20
Alumina	14·22	14·01	14·12
Ferric oxide	1·95	2·05	2·00
Ferrous oxide	7·39	7·43	7·41
Manganous oxide	1·30	1·19	1·24
Lime	11·53	11·47	11·50
Magnesia	8·26	8·11	8·19
Soda	2·63	2·56	2·60
Potash	·24	·23	·23
Titanic acid	1·61	1·55	1·58
Water	2·11	2·29	2·20
	99·49	99·04	99·27
Specific gravity			3·02

The analysis, taken with the observations made upon thin sections, shows that the rock is a mixture of pyroxene, chlorite, labradorite, and titanic iron, which are the constituents of diabase; and hence this metamorphic rock is appropriately distinguished by the name *metadiabase*. The absence of carbonate of lime is noticeable, showing that in this case the chlorite was formed simultaneously with the pyroxene, and not at the expense of the pyroxene, as in the case of the diabase of the trap dikes of the Connecticut valley, which always contains carbonate of lime as one result of the change. This rock in places contains pyrite, which is also frequent in trap.

PORPHYRITIC METADIABASE; SOUTH OF MALTBY PARK.

	I.	II.	Mean.		Diabase of Saltonstall Ridge.
Silica	48·57	48·65	48·61		49·28
Alumina	17·78	17·85	17·81		15·92
Ferric oxide	·35	·16	·25		1·91
Ferrous oxide	8·44	8·48	8·46		10·20
Manganous oxide	·20	·20	·20		·37
Lime	11·17	11·14	11·16		7·44
Magnesia	7·78	7·74	7·76		5·99
Soda	2·73	2·82	2·77		3·40
Potash	·47	·47	·47		·72
Titanic acid	1·35	1·35	1·35	CO_2	1·14
Water	1·60	1·65	1·63		3·90
	100·44	100·51	100·47		100·27
Specific gravity			3·01		2·86

There are varieties of this rock intermediate between these two, some specimens of which are beautifully porphyritic. In some kinds the feldspar is free from impurities; but in those varieties which are very feldspathic, and the feldspar crystals largest, these crystals are quite impure from the envelopment of chlorite. The porphyritic rock, from an outcrop near the Orange road, just south of Maltby Park, containing clear crystals of feldspar, was analyzed, and the result is given on the preceding page. An analysis of the diabase of Saltonstall Lake, from my former paper, is added for comparison.

This porphyritic ro:k is composed of the same minerals as the more compact varieties, for all of the ingredients can be easily recognized under the microscope. The possible presence of anorthite in the rock is suggested by the following analysis of some large grains of feldspar taken from an adjoining rock: SiO_2 45·52, Al_2O_3 29·84, MgO 2·35, CaO 15·99, NaO 1·61, KO ·37, ignition 2·38 = 98·06. This analysis was made by Mr. E. S. Dana some years since, but he states that the microscopic examination, and the analysis itself, show that the grains were very impure crystals of a triclinic feldspar, and as all the calculations upon the analyses point to the presence of labradorite, we cannot assume that any of the rocks which have been analyzed contain anorthite, though it is very likely to exist in the rocks of the series, since a constant composition in the feldspar could not be expected in the different layers of a rock made up of shifting sediments.

3. *Metamelaphyre*—a specimen taken from an outcrop on Stoeckel's farm is so fine grained as to appear nearly cryptocrystalline; it is broken into angular fragments like some of our trap rocks, and in fact resembles some compact trap so closely as to make it impossible to distinguish it by the eye alone. Its analysis afforded the following results:

METAMELAPHYRE, FROM STOECKEL'S FARM.

	I.	II.	Mean.
Silica	55·03	55·10	55·07
Alumina	14·38	13·98	14·18
Ferric oxide	7·15	7·25	7·20
Ferrous oxide	1·85	1·99	1·92
Manganous oxide	·30	·30	·30
Lime	9·05	9·01	9·03
Magnesia	6·02	5·94	5·98
Soda	4·08	4·14	4·11
Potash	·38	·37	·37
Titanic acid	1·56	1·56	1·56
Water	·68	·75	·72
	100·48	100·39	100·44
Specific gravity			2·99

If we assume that the pyroxene of this rock has the same composition as that of No. 1, we calculate, from the magnesia that it contains, 44 per cent of this ingredient; then, deducting three per cent of titanic iron, we have left a remainder of 53 per cent, which has very exactly the ratio and composition of oligoclase. This mineral constitution appears to be justified by the microscopic examination, since no free quartz or other mineral can be detected. If we restrict the use of the term melaphyre, as it is done in some recent works on lithology, to a mixture of oligoclase and pyroxene, with some titanic iron, the rock here analyzed is melaphyre in composition as well as appearance; and being a metamorphic rock, it is *metamelaphyre*.

We thus have representatives of the larger part of the pyroxenic igneous rocks, in positions which show conclusively that they are of metamorphic origin. The fact that metamorphic action can produce rocks exactly like the igneous in external aspect and chemical constituents is of great interest in the study of rocks.

ART. XIV.—*On a new Tertiary Lake Basin;* by GEORGE B. GRINNELL *and* EDWARD S. DANA.

SEVERAL Lake Basins of Tertiary age have already been discovered in the Rocky Mountain region, and the more important of them have been carefully explored. Those of Eocene age have only been known since 1870, but the Miocene deposits of the White River have long been noted for their wonderful scenery, as well as for the number and variety of the mammalian remains found in them. Another Miocene basin is known in Oregon, and both the lake beds of this period are overlaid by deposits of Pliocene age.*

During the explorations carried on last summer under the direction of Col. Wm. Ludlow, Corps of Engineers, a series of Tertiary deposits were identified by the writers near Camp Baker, Montana. These deposits indicate the existence in this region of a Miocene lake basin, which was succeeded by another lake basin in Pliocene time. As these basins are quite distinct from those heretofore known, it is considered important to put the fact of their discovery on record.

Camp Baker is situated on Deep Creek, a stream which flows into the Missouri River above Sun River. It lies about fifty miles nearly due east of Helena. It is surrounded on all sides by mountains, of which the Big Belt Range, lying immediately to the south or southwest, is the highest and most conspicuous.

* This Journal, III, vol. ix, p. 49, Jan., 1875.

The Little Belt Mountains lie to the north, and the Crazy Woman Mountains to the southeast, though at a greater distance.

The Tertiary beds found here consist for the most part of homogeneous cream-colored clays so hard as to be with difficulty cut with a knife. The beds are horizontal and rest unconformably upon the upturned yellow and red slates below. The clays of which they are formed resemble closely those found in the Miocene beds at Scott's Bluffs near the North Platte River in Wyoming. The deposits at Camp Baker have been extensively denuded and nowhere reach any very great thickness. At a point about three miles southeast of the Post, some bluffs were noticed where the Miocene beds attained a thickness of 200 feet, and these were capped by fifty feet of Pliocene clays, both beds containing characteristic fossils. In the underlying Miocene beds were found a species of *Rhinoceros*, several species of *Oreodon* Leidy and *Eporeodon* Marsh, a canine tooth apparently of *Elotherium* Pomel, and remains of Turtles. In the Pliocene beds the principal fossils were a species apparently of *Merychyus* Leidy, remains of an equine smaller than the modern horse, and Pliocene Turtles. These fossils have not yet been carefully studied, and for this reason their relations to the remains found in the other lake basins of similar age cannot here be stated.

We saw the first exposures of these beds a few miles west of the Sulphur Springs, just after crossing a rather high ridge of trachyte through which Deep Creek flows in a narrow and picturesque cañon. This point is about six miles southeast of Camp Baker. From here the lake bed was traced continuously along Deep Creek for a distance of fifteen miles, extending quite up to the mountains on the eastern side at least. Beds of the same character, containing similar fossils, were found on White Tailed Deer Creek, a branch of Deep Creek, about seven miles to the north of Camp Baker, as well as on Camas Creek to the southwest of the Post. Traces of this deposit, containing what appear to be remains of *Rhinoceros*, were also found two miles or more south of Moss Agate Springs, and at a considerable elevation above the creek bed. With more time than we had at command they could no doubt have been traced much farther, although in many places the beds have been washed out, or have been covered by the later local drift.

These Tertiary beds were all laid down after the elevation of the mountains and the igneous eruptions. They are, as has been said, perfectly horizontal, and are often seen covering over ridges of trachyte. The line of separation between the Miocene and Pliocene beds is in some places well marked. It consists of about six feet of hard sands, interstratified with

layers of very small water-worn pebbles soldered together into a hard mass, but easily picked out with a knife. Each of these layers is about six inches in thickness. Immediately above these strata the Pliocene fossils were found. In several places fragments of trachyte were noticed in the Pliocene beds.

Near Camp Baker are a series of upturned ridges of Potsdam sandstones and limestones at a level very little above that of the Tertiary beds, and doubtless in this region the lake was divided into many arms, which bent around, and extended among, these ridges.

It is known that in the neighborhood of Fort Shaw, and near Helena, Pliocene deposits exist, and at Fort Ellis and in the valley of the Yellowstone we saw, but were unable to examine, gray sands and marls, which Dr. Hayden refers to the same age. No Miocene beds, however, have been identified at any of these localities. It seems probable that in Pliocene time at least, the Baker Lake may have extended north to the Missouri River, and perhaps up that stream to the Three Forks, thus connecting with the lake which existed near Fort Ellis. Indeed it would seem that we just touched upon the southern edge of this basin, which may have extended far to the north and west.

An interesting point in connection with these deposits, is the fact that they are at a much greater elevation than any other beds of the same age now known on the continent. The elevation of the White River and Colorado beds is about 3,000 feet, and that of the Oregon basin somewhat less, while that of the deposits near Camp Baker is over 5,000 feet.

In reference to the relations which this lake basin bears to the Oregon basin and to the White River deposits, nothing can be certainly known without a careful exploration of the whole region and a thorough study of its vertebrate remains. It is by no means impossible that the Baker Lake may have flowed into that at White River by some old river channel, but so little is known of the intervening country that no definite opinion can be pronounced on the subject.

ART. XV.—*Communications from the Laboratory of Williams College.* No. IV.—*On the Product of the action of Potassium on Ethyl Succinate;* by IRA REMSEN.

IN a notice published a short time ago in this Journal,* I described a few preliminary experiments, undertaken with the object of discovering the structure of a peculiar substance which is produced when potassium is allowed to act upon ethyl succinate. Since the time of the first publication, I have been engaged in prosecuting this investigation, the results of which are herewith communicated. The communication is hastened by the fact that quite recently a similar investigation has been undertaken in the laboratory of Wislicenus,† and in the publication of the experiments no reference is made to my work.

1. *Preparation and Properties.*

The substance under consideration was first obtained by v. Fehling‡ in the course of an exhaustive examination of the compounds of succinic acid. I give his description of the method of obtaining the substance: "If ethyl succinate, which has been thoroughly dried by means of calcic chloride, is brought in contact with potassium or sodium, the metal becomes oxidized, and the ether is decomposed. At the ordinary temperature the decomposition takes place more readily with potassium than with sodium. The action begins instantaneously; an inflammable gas is evolved which conducts itself like hydrogen. By gently heating the action is hastened; the mass becomes heated spontaneously, and care must hence be taken not to heat higher than 30–40° at first. In connection with the reaction a peculiar penetrating odor is perceived. If the action is too violent, the mass may easily be thrown out of the vessel in which it is contained."

"If sufficient potassium has been added the mass becomes thick and viscid, and the color of the mass is brown. This color appears to arise from secondary decomposition-products."—"If water is now added to the mass, and it be heated rapidly to boiling, a clear, yellow liquid is obtained, upon which an oily, yellowish layer floats; but it seems to be important not to heat for too long a time. The liquid congeals on cooling, forming a soft, pasty mass. By means of a filter the liquid is separated from a yellow crystalline mass, and the residue washed out with water."—"The yellowish residue upon the filter is purified by repeated recrystallizations from alcohol.

* Vol. ix, p. 120. † Berliner Berichte, viii, Jahrgang, 1039.
‡ Annalen der Ch. Pharm., xlix, 192.

The crystalline mass is now white with a slight tinge of yellow, possessing a beautiful satin-luster, and is very voluminous."

The analyses made agreed closely with each other and led to the formula $C_6H_8O_3$.

"The compound does not dissolve in water. Alcohol dissolves it readily, particularly with the aid of heat; cold ether dissolves it in every proportion. By heating with alkalies this product is decomposed, alcohol is given off which can easily be recognized by the odor; and a yellow solution is obtained, similar to that which was obtained at first by treating with water the mass which was produced by the action of potassium upon the ether. This solution contains potassic succinate." "The crystalline body fuses at 133° and sublimes completely at 206°. With ammonia this product forms a bright yellow body crystallizing in needles."

Since the time of the publication of the investigation of v. Fehling, this substance does not appear to have been reëxamined. Only Geuther* has indulged in some speculations in regard to its structure, though his speculations are not based upon new experiments. He proposed to double the formula of v. Fehling making it $C_{12}H_{16}O_6$, and then suggested that the compound was either disuccinic ether or diethyldisuccinic acid.

In view of the peculiar method of its formation, it seemed desirable to learn something more definite in regard to the chemical conduct of the body, and accordingly I prepared a considerable quantity of it and subjected it to examination. The statements of v. Fehling in regard to its preparation were found to be in the main correct. It is not a simple matter to tell when the reaction between the metal and the ether is at an end, as the mass becomes very thick, even while warm, and, the metal becoming covered with a layer of the fully decomposed mass is kept from further action. It is very important too, not to have an excess of the metal, for, as we shall see, the new subtance forms with potassic hydroxide, a compound which is easily soluble in water, and is also easily decomposed by the hydroxide, if the temperature is raised. I found it sufficient to recrystallize the product but once from alcohol, obtaining it thus almost pure, either in the form of laminæ with a strong luster, or of needles of considerable length. The alcoholic solution exhibits the property of fluorescence to a marked degree, but I have noticed that this property grows less marked the purer the compound becomes. The fusing point of the compound is given at 133° by v. Fehling, whereas I found it to be at 128°.

* Zeitschrift für Chemie, 1866, 5.

2. *Metallic Compounds.*

When sodium-amalgam is allowed to act upon the alcoholic solution of the compound, there is produced a voluminous red precipitate, which is very easily soluble in water. From the aqueous solution, chlorhydric acid precipitates a white substance which is insoluble in water and difficultly soluble in alcohol. This substance proved to be the original compound. The same red precipitate is produced when alcoholic solutions of the compound and potassic hydroxide are brought together, and a similar precipitate when sodic hydroxide is used instead of potassic hydroxide. The latter precipitate was first prepared for examination.

Sodium-Compound, $C_{12}H_{14}Na_2O_6 + 4H_2O$.

This compound was prepared by bringing together alcoholic solutions of the original body and sodic hydroxide. It is thrown down immediately, as a beautiful red precipitate. This precipitate consists of microscopic needles. It was filtered off and washed out with alcohol. In drying, the color changed from red to yellow, but it appears as though this change of color is not accompanied by a chemical change. The analyses gave the following results:

I. 0·201 grams of the substance gave 0·08 grams Na_2SO_4 = 0·0259 grams Na.

II. 0·1202 grams of the substance gave 0·048 grams Na_2SO_4 = 0·0155472 grams Na.

		Calculated.	Found.	
$C_{12}H_{14}O_6$	254	68·28	....	....
Na_2	46	12·37	12·89	12·93
$4H_2O$	72	19·35	....	....
	372	100·00		

According to this, the substance has the formula $C_{12}H_{14}Na_2O_6 + 4H_2O$. It is very easily soluble in water, and the body, $C_{12}H_{16}O_6$, is precipitated from this solution on the addition of an acid. By boiling with a little sodic hydroxide succinic acid is formed.

The corresponding potassium compound is mentioned by Wislicenus (loc. cit.) Another potassium compound of the formula $C_{12}H_{15}KO_6$ is also mentioned, the existence of which speaks clearly for the formula $C_{12}H_{16}O_6$ for the original substance, instead of the simple formula $C_6H_8O_3$.

Barium-Compound, $C_{12}H_{14}BaO_6 + H_2O$.

If an alcoholic solution of the substance $C_{12}H_{16}O_6$ is added to baryta water, a beautiful rose-colored precipitate is pro-

duced, similar to that produced with sodic hydroxide. This was filtered off from the solution of baryta-water and rapidly washed out with hot water. During the process of filtration the surface of the liquid on the filter was carefully protected from the influence of the air by a perforated cover which was connected with a tube containing potassic hydroxide. After all baryta had been washed away, the residue was boiled with alcohol, and again rapidly filtered in order to remove any uncombined $C_{12}H_{16}O_6$. It was then dried and analyzed with the following results:

0·1904 grams of the substance gave 0·1085 grams $BaSO_4$ = 0·065798 grams Ba.

		Calculated.	Found.
$C_{12}H_{14}O_6$	254	62·10	....
Ba	137	33·50	33·51
H_2O	18	4·40	....
	409	100·00	

The formula is therefore $C_{12}H_{14}BaO_6+H_2O$. The compound is very stable. As was seen above it can be boiled with alcohol or water without undergoing decomposition. It is, however, decomposed by acids just as the sodium-compound is, the substance $C_{12}H_{16}O_6$ being precipitated.

Calcium-Compound, $C_{12}H_{14}CaO_6+H_2O$.

If lime-water is used instead of baryta-water, a precipitate is produced, which is, however, of a beautiful lemon-yellow color. This was purified in the same manner as the barium-compound. The analysis gave the following numbers:

0·2172 grams of the substance gave 0·0937 grams $CaSO_4$=0·0275 grams Ca.

		Calculated.	Found.
$C_{12}H_{14}O_6$	254	81·41	....
Ca	40	12·82	12·67
H_2O	18	5·77	....
	312	100·00	

Magnesium-Compound.—When the body $C_{12}H_{16}O_6$ is boiled in water with magnesia, a purple compound is produced, which resembles the above described compounds in many respects. This is probably the same compound that is mentioned by Wislicenus as having been prepared in another way.

We have here then a series of peculiar metallic compounds, which are not salts in the usual acceptation of that term. The substance $C_{12}H_{16}O_6$ is not an acid; at least it does not contain the group COOH, for it is entirely unaffected by the alkaline carbonates, and, its metallic compounds are themselves

decomposed by carbon dioxide. Wislicenus proposes the formula

$$\begin{array}{l} CH_2.CO.CH.CO.O.C_2H_5 \\ | \qquad\quad | \\ CH_2.CO.CH.CO.O.C_2H_5 \end{array}$$

for the original compound, according to which it is ethyl succinylsuccinate, a derivative of succinylsuccinic acid. The metallic compounds are explained by supposing the hydrogen atoms of the groups CH to be replaced by the metals, the hydrogen in these groups having a somewhat acid character. It seems to me that the great stability of the ether which we have above recognized speaks against this formula. Most acids, which consist of atoms grouped in the manner indicated by the above formula, are decomposed by boiling with baryta-water, whereas we have seen that this substance may be boiled with baryta-water without undergoing decomposition. It is true that we know very little concerning bibasic acids of this structure, and it is possible that what is true of the monobasic acids is only partially true of the bibasic. Be this as it may, it is certain that the experiments thus far published will not permit the positive conclusion that the above formula is the true one, and further investigations would be called for whether the formula is correct or not.

3. *Action of phosphoric Chloride upon the body* $C_{12}H_{16}O_6$.

With the hope of learning something more definite concerning the nature of the oxygen-atoms contained in the substance under examination, I next undertook the study of the action of phosphoric chloride upon it. At first I employed two molecules of the chloride to one molecule of the substance. When the two are brought together in a dry vessel, no action ensues until heat is applied. If the mass is very gently heated, the substance $C_{12}H_{16}O_6$ melts, and immediately reaction commences, and continues then without the further aid of heat, until the contents of the retort form a clear, homogeneous liquid. The reaction is accompanied by an evolution of chlorhydric acid, the amount of which, however, was such as to leave me in doubt whether this was a necessary product of the reaction, or was formed from the secondary decomposition of the phosphorus compound which distilled over. The oxichloride of phosphorus was distilled off by gentle heat, and the oil in the retort then treated with water. Decomposition soon began and there resulted a solid, insoluble product. On examination this proved to be the original substance $C_{12}H_{16}O_6$. As the amount of this product was comparatively considerable, I at once concluded that a chloride had been formed by the first reaction which by its decomposition with water yielded the

mother-substance. This conclusion proved subsequently to be erroneous, in such a way as to show that the first error in judgment was partially excusable. In a second series of experiments, I employed four molecules of the chloride to one molecule of the substance, and thus reached new results. The same phenomena accompanied the reaction, that were noticed in the case already described. The direct product was a clear, yellow oil. This was treated with a little cold water. At first the oil simply fell to the bottom of the vessel, but in a short time decomposition commenced, and gradually the oil disappeared, a solid product remaining in its stead. On being filtered off and examined, the solid product proved to be a new acid, comparatively easily soluble in water. In the filtrate there was also contained a considerable quantity of the new substance, which was extracted by shaking with ether. The new acid crystallizes out of the concentrated aqueous solution in laminæ which are colored yellow. In alcohol it is exceedingly easily soluble. It dissolves in a little potassic carbonate, and is precipitated from the solution on the addition of a few drops of chlorhydric acid.

As this product is easily soluble in water, it is plain that it escaped me in the first experiment, by remaining dissolved in the water which served for the decomposition of the chloride, a sufficient quantity of water having been employed to dissolve the whole of the product, if the conversion of the substance $C_{12}H_{16}O_6$ into the chloride had been complete. That which was really found in the first experiment was simply a part of the original substance, which had not been acted upon by the chloride of phosphorus.

If we attempt to distil the chloride for the purpose of purification the mass is completely carbonized. A few drops of a colorless liquid boiling at a high temperature pass over, but the quantity of this liquid is too small to admit of an examination. It is decomposed by water, and the product is solid. It was impossible to determine the nature of the solid, owing to the small quantity obtained. It is not probable that it was succinic acid, for, in that case, the chloride from which it was obtained would have become solid at a low temperature, whereas it remained liquid even when cooled down to 0°.

If the product of the action of phosphoric chloride on the substance $C_{12}H_{16}O_6$ is heated for some time, it gradually becomes solid, or nearly so, and then has the appearance of a translucent resin. I analyzed this compound, but the numbers obtained did not agree in different analyses. It appears, thus, that condensation and decomposition of the chloride are caused by heat.

As the most important result of these experiments with

phosphoric chloride, then, we see that, if four molecules of the chloride are caused to act upon one molecule of the substance $C_{12}H_{16}O_6$, a liquid chloride is formed which is decomposed by water yielding a new acid. I have not yet studied this new acid, and can, therefore, not state in what manner it is derived from the original substance. As it can apparently be prepared in any desirable quantity with comparatively little trouble, its examination will probably give interesting and positive results.

In addition to the results already recounted, I will mention the following:

1. *Acetyl chloride* exerts no influence upon the substance $C_{12}H_{16}O_6$. It simply dissolves it when gentle heat is applied, but, on cooling, the unchanged substance crystallizes out. This result could be anticipated with considerable certainty, as the presence of alcoholic hydroxyl in the substance was not at all probable. Still the experiment was necessary to prove the fact, no matter how probable it might appear.

2. *Ammonia* does not act upon the substance either in aqueous or alcoholic solution. v. Fehling (loc. cit.) states that with ammonia the body yielded a bright yellow compound crystallizing in needles. I endeavored in vain to obtain such a compound. I first boiled the substance with very strong aqueous ammonia; it remained unchanged. I then conducted dried ammonia gas into an alcoholic solution of the substance. The solution turned deep yellow in color, but I was unable to extract from it anything save the original substance. This indeed, sometimes crystallizes in needles—a fact which may have misled v. Fehling. By analogy we should expect the formation of a compound with ammonia corresponding to the metallic compound described above. It is possible that some change in the conditions may lead to its formation.

3. *Hydrogen* in the nascent state (from tin and chlorhydric acid) does not act upon the substance. If the group CO is present, it is difficult to see why this should not be converted into the secondary alcohol group CH.OH by the action of hydrogen.

4. A solution of *potassic permanganate*, as well as dilute *nitric acid*, oxidize the substance very slowly. The products of the oxidation I have not yet examined. In connection with the oxidation by means of potassic permanganate a peculiar phenomenon was noticed which deserves mention. I have stated that the oxidation took place slowly; the product was not an acid, so that the manganic oxide formed was precipitated; but, further, the substance oxidized was insoluble in water, so that the manganic oxide, being produced in contact with the

faces of the insoluble crystals, was deposited in even layers upon them, forming thus a complete envelope, and giving a genuine pseudomorph. I was at first deceived by this strange pseudomorph, believing it to be the product of the oxidation. It was insoluble in water, and appeared to be insoluble in alcohol. I found, however, afterward, that the alcohol dissolved the central portions of the pseudomorphs leaving the envelopes unchanged in form.

5. The substance was *heated with water* at 150° in a sealed tube. At this temperature decomposition took place, but not at a lower temperature. The products of the reaction were alcohol, and a solid, white crystalline substance which conducted itself in some respects like succinic acid. The alcohol was detected by placing the whole product in a flask and distilling with water. The distillate was tested by Lieben's reaction* for the formation of iodoform.

The experiments which have thus been described do not suffice to enable us to judge positively in regard to the structure of the substance under investigation. I have stated above the view held by Wislicenus, and also my objections to this view. It remains yet to be decided whether my objections are well founded, and this can be done only by the aid of new experiments.

No. V. *On the action of Ozone on Carbon Monoxide;* by Ira Remsen and Mase S. Southworth.

One of the most remarkable examples of so-called non-saturated compounds is carbon monoxide. If we accept the hypothesis of constant valence, the compound CO must possess free affinities, or, as some chemists believe, the two affinities of the carbon-atom, which are not saturated by the oxygen atom, must exercise an influence upon each other. We can not explain this case by assuming that two carbon-atoms are joined together by two affinities each, for we know that the formula of carbon monoxide is CO, and not C_2O_2 or a higher multiple, and, accepting this formula, it is plain that we cannot assume a double union of carbon atoms in the compound.

If, on the other hand, we accept the hypothesis of variable valence, believing that the valence of an element depends upon circumstances, we shall look in vain for circumstances which, in the one case, can cause the bivalence, in the other the quadrivalence, of the carbon-atom. A difference in temperature certainly does not cause the difference in valence. The atom

* Annalen der Chemie, Suppl. VII, 218.

of carbon is quadrivalent toward oxygen at the ordinary temperature and under ordinary conditions. How otherwise shall we explain the formation of carbon dioxide in the processes of decay, fermentation, etc.? But the atom of carbon is just as positively quadrivalent at high temperatures.

The comparative ease with which carbon monoxide takes up chlorine appears to prove that it possesses free affinities. But if we accept this as a proof of the existence of free affinities in carbon monoxide, we have still better grounds for believing that free affinities are present in ethylene, for this gas combines with chlorine much more readily than carbon monoxide does. Still the view is commonly held that in ethylene the two carbon-atoms of the molecule are united by the mutual action of two affinities of each atom.

These considerations show that the nature of carbon monoxide is, as yet, but very unsatisfactorily understood. The first question which suggests itself is this: How far are we justified in considering carbon monoxide as a body possessing free affinities?

If we attempt to answer this question entirely without prejudice, we see that the principal experiment which is supposed to prove the existence of free affinities in carbon monoxide is the above mentioned experiment with chlorine. Oxygen does not combine with carbon monoxide at the ordinary temperature. This is readily understood, for, in order that the carbon monoxide and oxygen may combine by direct contact of the two substances, the oxygen-molecule must first be decomposed into its constituent atoms. An interesting experiment in this connection has been described by E. Ludwig,* who shows that carbon monoxide is oxidized by chromic acid at the ordinary temperature forming carbon dioxide. In this case carbon monoxide is active enough to separate one atom of oxygen from chromic acid and to employ it for the formation of carbon dioxide.

We have occupied ourselves with an experiment similar to that described by Ludwig, and have obtained a different and unexpected result. It appeared to us to be of interest to know whether, at the ordinary temperature, ozone has the power to transform carbon monoxide into the higher oxide. According to the views which are commonly held concerning the nature of the substances experimented upon, the transformation mentioned could be predicted with a tolerable degree of certainty. Particularly is this the case, if we consider the result of Ludwig's experiment, for usually ozone gives up its extra atom of oxygen with still greater readiness than chromic acid does. There is indeed no substance in the whole field of chemistry which furnishes us with a better means for obtaining

* Annalen der Ch. u. Pharm., clxii, 47.

a free atom of oxygen than ozone. If then we bring in contact with ozone a substance, which in turn is capable of taking up an atom of oxygen without itself undergoing change; which, indeed, possesses an attraction for oxygen, we are certainly justified in expecting to see the two substances act upon each other. But the experiment gave the unexpected result that ozone does not act upon carbon monoxide.

Two very careful experiments were performed. Pure carbon monoxide free of dioxide was first collected in a gasometer. This was then conducted from one side through three cylinders containing potassic hydroxide and lime-water into a flask. From the other side a current of oxygen was conducted through potassic hydroxide and lime-water, and then through a tube, in which the oxygen was converted into ozone, into the same flask. This flask was provided with a stopper having three holes. From the third hole a tube led to a cylinder containing lime-water; and this cylinder was connected with a final cylinder containing potassic hydroxide. Let us see what purposes the different parts of the somewhat complicated apparatus served. In the first place, the carbon monoxide was caused to pass through potassic hydroxide and lime-water in order to absorb every trace of carbon dioxide which might be present. The oxygen was treated similarly for a similar purpose. The ozone generator employed was that described by Wright* for use with the Holtz electrical machine, the best conditions being retained throughout the experiment for the working of the apparatus. The pure carbon monoxide and the ozonized oxygen were then caused to meet in the final flask, the inside of which was moist, as, for some unknown reason, ozone does not exhibit its oxidizing properties as well when dry as when moist. The mixture of the two gases, and any carbon dioxide which might have been formed, were then passed together into lime-water, contained in a cylinder, the lime-water being protected from the influence of the carbon dioxide of the air by the potassic hydroxide contained in the last cylinder.

Slow currents of carbon monoxide and oxygen were now passed through the apparatus, and, although the action was continued for a long time, not a trace of a precipitate could be detected in the last cylinder, containing lime-water. The strength of the gas-currents was frequently changed, but nothing brought about the expected result.

In view of the importance of the experiment we were not satisfied with this one form of it. As direct sun-light greatly facilitates the combination of carbon monoxide with chlorine, it seemed probable that it would be of service in causing the combination of the two gases under examination; and, accord-

* This Journal, vol. iv, July, 1872.

ingly, we repeated the described experiment with the following modifications: The final flask, above mentioned, in which the carbon monoxide and the ozone were brought together, was replaced by two large glass balloons, and these were placed in the direct light of the sun. Again slow currents of carbon monoxide and ozone were passed through the apparatus for hours, the rapidity of the currents being varied at different times.

In this case also we obtained only a negative result. We hence are in a position to assert positively that carbon monoxide is not oxidized by ozone.

If we now bear in mind that ozone acts destructively upon a great many saturated stable compounds, that one of the atoms of the ozone molecule has a great tendency to unite with other bodies, then the result of the above described experiments remains inexplicable. It shows at all events that carbon-monoxide itself, at the ordinary temperature, has no very great tendency to unite with oxygen, for, if our ideas in regard to the nature of ozone are correct, the conditions for such union were very favorable in our experiment.

We hope gradually to be able to experiment more fully upon this interesting subject with the object of collecting material which may enable us better to understand the nature of the so-called non-saturated compounds. We propose next to study the action of hydrogen peroxide upon carbon monoxide.

December, 1875.

ART. XVI.—*Mineralogical Notes*; by EDWARD S. DANA.—No. I. *On the Optical Character of the Chondrodite of the Tilly Foster Mine, Brewster, New York.*

IN a memoir on the Brewster chondrodite, published in the third volume of the Transactions of the Connecticut Academy, I have given the results of an optical examination of chondrodite crystals of the *second* type.* It was there shown that the optic axes lie *not* in the basal plane, but in a plane making an angle of about 154° 10′ with the base; and, in consequence, that the crystals of this type, at least from that locality, belong optically not to the orthorhombic system, but to the *monoclinic*, while the various measurements proved that the deviation in angle from the orthorhombic type could not be greater than 2 or 3 minutes. A recent repetition of the measurements with the stauroscope on the same crystals, and also on another not examined before, confirm the results ob-

* See also this Journal, III, ix, 63, for extracts from the paper.

tained, and leave no room for doubt on the subject. The following is the evidence on this point thus far obtained.

Measurements on four independent crystals gave for the supplement angle made by the plane of the axes:

I.	With $e^1(\frac{2}{3}\text{-}\breve{i}=203)$, 18° 9′;	hence with basal plane,	25° 50′.
	With $e^2(2\text{-}\breve{i}=201)$, 45° 9′;	" " " "	25° 46′.
II.	With $e^a(\frac{2}{5}\text{-}\breve{i}=205)$, 40° 55;	" " " "	25° 59′.
III.	With $B\,(i\text{-}\breve{i}=100)$, 65°–70°;	" " " "	20°–25°.
IV.	With the basal plane, direct measurement,		25°.

I have since made an optical examination of a crystal of the third type. One single crystal of this type allowed of a stauroscopic examination. Only a small portion of it was transparent enough for use, but the circumstances allowed of a very exact adjustment according to the method of Groth, and the probable error cannot exceed one degree. The measurement gave for the supplement angle between the base and the plane of two of the axes of elasticity 7½°, a result which, like the corresponding one obtained for the second type, is at variance with the supposed orthorhombic character of the species. The series of measurements were made at different times with independent adjustments, but no considerable variation was found in the result, so that it may be considered as being above question. It is remarkable that the correspondence between the two types is not greater. In crystalline form the third type is between the first and second. I have to regret that no satisfactory material is at hand for the extension of these investigations to the Vesuvian humite.

It may not be out of place to state here that, through the kindness of Mr. Cosgriff, the Yale College Cabinet has recently received some exceptionally large crystals of chondrodite from the Tilly-Foster Iron Mine. The crystals were quite perfect, and four inches or more in length. Like all the large crystals they are partially altered, and have therefore little luster. They are penetrated with serpentine and brucite derived from their alteration.

ART. XVII.—*On Hermannolite, a new species of the Columbium group;* by CHARLES UPHAM SHEPARD, Sr., Mass. Professor of Natural History in Amherst College.

IN vol. 1, p. 90, of this Journal (1870), I described as probably new, a Columbium mineral from Haddam, Connecticut, to which in June last* I gave the name of Hermannolite, in honor

* See Popular Guide to the Museums of Amherst College, p. 71.

of Dr. R. Hermann of Moscow, to whom chemistry has been so much indebted for the elucidation of this difficult group of minerals. By reference to my description of the mineral it will be seen that I went no further than to determine the proportions of the bases, and of the metallic acids with which they were united, without attempting to ascertain the order in which the latter were present. I thus found:

Metallic acids,	78·30
Protoxide of iron,	13·86
Protoxide of manganese,	7·72
	100·28

Desirous of learning the exact proportions of the different acids, I availed myself of an opportunity during the past summer of sending specimens to Mr. Hermann for this purpose. He has had the goodness to perform the analysis, and to communicate to me his results in the following letter.

"Your opinion that the mineral from Haddam, which you most kindly named for me, was not columbite has been fully corroborated: for it contains no hyponiobous acid (Nb^2O^3), as the columbite does; but niobous acid (NbO^2); and, in addition, hypoilmenic acid (Il^2O^3), and also, a small quantity of hypotantalic acid (Ta^2O^3). The chemical formala is therefore quite different from that of the Columbite: i. e., *not* RO, Me^2O^3, but

$$2(2RO, 3NbO^2)+(RO, Me^2O^5)Il^2O^5=(\tfrac{1}{4}Ta^2O^5+\tfrac{3}{4}Il^2O^5).$$

The result of the analysis was:

		Oxygen.		Calculated.
Hypotantalic acid,	7·029	1·301	5·427	5·0
Hypoilmenic acid,	14·917	4·126		
Niobous acid,	56·154	12·290		12·0
Protoxide of iron,	12·560	2·79	4·89	5·0
Protoxide of manganese,	9·340	2·10		
	100·000			

The lower specific gravity of the mineral observed by you as well as the easy solubility in sulphuric acid of the metallic acid present, are readily explained from their small content of tantalic acid, and from the greater proportion of oxygen in the niobous acid as compared with that of the hyponiobous acid in Columbite."

Moscow, Nov. 9, 1875.

The physical characters of the mineral are given in the volume of this Journal above referred to.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Didymium absorption-spectrum and the Atomic weight of Cerium.*—Bührig has examined the methods for the preparation of pure cerium and has made an elaborate determination of its atomic weight. As the absorption spectrum of didymium is so characteristic, the author made a careful study of it, with a view to use it to prove the freedom of the cerium from this metal. The pure sulphate in a tube 22 cm. long (1·0454 grams in 50 c. c. of water) gave 11 bands. Upon dilution, it was found that in this tube $\frac{1}{7174}$ gram of the sulphate in 100 c.c. water—corresponding to $\frac{1}{17842}$ gram Di,—could be detected by its bands. In a tube 52 cm. long, $\frac{1}{21139}$ gram of sulphate, corresponding to $\frac{1}{54645}$ gram of didymium, could be thus detected. Using a Duboscq, in place of the Hoffmann spectroscope, three additional absorption lines were observed, making in all 14. The spectrum given by a crystal of sulphate 0·9 mm. thick, contained 22 lines, and was considerably different from the others. Plates of these spectra are given. The cerium was obtained pure from the mixed oxalates of the cerite earths, by igniting these without the addition of magnesia, by solution in nitric acid, and precipitation of the cerium as ceroso-ceric sulphate. This precipitate, after washing, was obtained free from didymium by Gibbs' method. The atomic weight of cerium was determined from the combustion of the oxalate and was found to be, as a mean of ten closely concordant results, to be 94·1782. The author adds some analytical data concerning the salts of cerium.—*J. pr. Ch.*, II, xii, 209, Nov., 1875. G. F. B.

2. *On the Density of Platinum, of Iridium and of their Alloys.*—Sainte-Claire Deville and Debray have prepared with great care both platinum and iridium in a state of purity and have determined the density of these metals as well as that of several of their alloys. The methods which they made use of to purify these metals are given at length in their memoir. The platinum ingots weighed from 200 to 250 grams, and gave a density of 21·5. The iridium, after breaking under the rolls, had a density of 22·42104; in the ingot, as melted, of 22·239. An alloy of 90 per cent of platinum and 10 of iridium had a density of 21·615; of platinum 85 and iridium 15, of 21·618; of 66·67 platinum and 33·33 iridium, 21·874; of platinum 5 and iridium 95, 22·384; thus increasing quite regularly.—*C. R.*, lxxxi, 829, Nov., 1875.

G. F. B.

3. *New method of Chlorinating Hydrocarbons.*—In the course of experiments made to discover a solvent for the comparatively unstable molybdenum pentachloride, Aronheim observed the energy with which it transferred its chlorine, even benzol when heated with it evolving torrents of hydrochloric acid gas. Further

examination showed it to be a far more energetic chlorine-carrier than iodine, since (1) it acts more readily and quickly, (2) it carries the process more uniformly from one stage to the next, and (3) it can be more readily removed from the products. If to 500 grams anhydrous benzol, 5 grams $MoCl_5$ be added, and a stream of chlorine be passed through it, heat being applied by a water-bath and a return-cooler being used, after three days the liquid solidifies on cooling to an intermixed crystal mass, consisting of nearly pure para-dichlor-benzol, which after purification is equal in weight to the benzol taken. By acting on toluol in this way, the author in conjunction with DIETRICH, has obtained several new chlorine derivatives of this hydrocarbon.—*Ber. Berl. Chem. Ges.*, viii, 1400, Nov., 1875. G. F. B.

4. *On the Effect of Mass on the Chemical action of Water.*—OSTWALD has made, in the laboratory of the Dorpat University, a research upon the action of water in mass upon chemical action. A concentrated solution of bismuth chloride in hydrochloric acid was divided into 25 equal portions. To the first, water was added till a permanent turbidity appeared, and quantities of water gradually increasing from this were added to the other portions, the last receiving enough to precipitate all the bismuth. After standing six weeks, the various liquids were separately analyzed, the chlorine, bismuth, hydrogen and water being determined. These results are given in a table. To compare them a second table is given in which the chlorine and bismuth are calculated for 100 parts of water. If from these figures a curve be constructed with those for bismuth as abscissas and chlorine as ordinates, the form of the curve for two-thirds of its length is a hyperbola. The first third is nearly a straight line, differing from this no more than is allowed by experimental errors. Hence either Berthollet's law is true and the action is exactly proportional to the mass, the curve being due to foreign influences, or the law of the action of mass is a function of a higher order, and Berthollet's law only a special case of it, where the higher powers are neglected. The author inclines to the former view; since he has detected one such disturbing cause in the fact that considerably more of the bismuthyl chloride remains suspended in the diluter than in the more concentrated liquids.—*J. pr. Ch.*, II, xii, 264, Nov., 1875. G. F. B.

5. *Formation of Alizarin by Reduction of Rufigallic Acid.*—WIDMAN has observed that when rufigallic acid is reduced by sodium amalgam, a violet solution is obtained. On precipitating this by hydrochloric acid and dissolving the precipitate in potassa, barium chloride throws down a second precipitate, which when treated with HCl leaves a residue. This dissolved in methyl alcohol or acetic acid, is left on evaporation. Heated to 250°, it sublimes in brilliant orange-red needles, having all the reactions of alizarin. Hence rufigallic acid is hexa-oxyanthraquinone $C_{14}H_2\left\{\begin{matrix}(C)''_2\\(HO)_6\end{matrix}\right.$, and the production of alizarin in the vegetable kingdom, is explained.—*Bull. Soc. Ch.*, II, xxiv, 359, Nov. 1875. G. F. B.

6. *On the Separation of Mixed Liquids.*—DUCLAUX has made a careful study of the conditions under which a homogeneous mixture of two liquids will separate into two entirely distinct layers, and has arrived at some very curious results. He finds, for instance, that a mixture of 15 cubic centimeters of amyl alcohol, 20 cubic centimeters of ordinary alcohol and 32·9 cubic centimeters of water, gives at the temperature of 20° C., a molecularly unstable grouping, so that the least diminution of temperature causes it to separate into two nearly equal layers: He states that under these conditions the composition of the two layers is invariably the same whatever the composition of the initial liquid, the layers varying only in amount. The same fact is also true of three as of two liquids; though in this case the third liquid takes no part in the separation, and remains the same in each of the two layers as in the original liquid. Hence it is always possible to start with a given liquid such that by depression of the temperature, two layers of the same volume are produced. The range of variation of temperature necessary to effect this separation is extremely minute, being much less than a tenth of one degree Centigrade! Moreover, the introduction of mere traces of certain substances, as sodium and calcium chlorides and other soluble salts, and the vapor of chloroform produce the same effect as a lowering of temperature. So also a drop of water or one of amyl alcohol will cause the separation. The author has applied this phenomenon to the construction of an ingenious minimum thermometer. By varying the amount of water present in the above mixture for example, the temperature at which separation ensues may be varied. The solutions may be readily prepared by taking the necessary quantities of amyl and ethyl alcohol, maintaining them at the exact temperature required and adding water drop by drop, until a slight turbidity appears, which should dissolve upon the slightest heating. The mixture is then placed in a tube and this is hermetically sealed. Ordinarily the liquid is clear but it becomes turbid as soon as the temperature falls below that at which it was prepared. A few drops of carmine in ammonia makes the separation more distinct, since the lower layer only is colored. If ten parts of ether be mixed with six of commercial methyl alcohol, and water be carefully added as above, a liquid will be obtained acting as a maximum thermometer, since it becomes turbid and separates when the temperature rises above that at which it was made. This is colored with a little blue ink. Several tubes of each kind would evidently be exceedingly useful in maintaining a given temperature constant for any purpose, since they could be graduated to any interval.—*C. R.*, lxxxi, 815, Nov., 1875. G. F. B.

7. *Stationary Liquid Waves.* Professor GUTHRIE has recently communicated to the London Physical Society the results of his observations on wave motion. If water in a cylindrical vessel, not less than nine inches in diameter, be agitated by depressing and elevating a flat circular-disk on its surface at the center, a form of

oscillation is set up which the author terms binodal. He finds that these fundamental undulations in an infinitely deep circular vessel are isochronous with those of a pendulum whose length is equal to the radius of the vessel, and that the pendulum and water keep together throughout their entire paths. This was shown experimentally by a short pendulum with a heavy adjustable bob, having a card-board sector attached to its upper end. A silk thread attached to the edge of this sector carries a small paraffin disk, which rests at the center of the surface of the water contained in the cylindrical vessel. The length of the pendulum is altered until the motion of the disk is isochronous with that of the water. Two other forms of motion may also be produced by alternately compressing and extending opposite diameters, as in a bell, and by rocking the vessel. Each has its own period, the last being the slowest. They may be superposed and a rotation of the water, however great, does not interfere with their formation.

In rectangular troughs binodal and mononodal waves may be formed, the former by raising and lowering a wooden lath at the middle of the surface, and the latter by tilting the vessel. Experiments of binodal motion show that they are isochronous with a pendulum whose length is 2 divided by π times that of the trough. The principal questions still to be considered are: (1) Why are the motions pendular? (2) How is it that in circular binodal motion the times are identical with that of a pendulum of given length? and (3) What is the mathematical connection between the individual motion of each particle and that of the mass?—*Nature*, xiii, 99. E. C. P.

8. *Waves in Elastic Tubes;* M. Marey has studied the laws of the circulation of the blood by a mechanical representation in which a liquid wave is made to traverse an elastic tube. The changes in the shape of the tube are measured at six points by small elastic reservoirs connected with a chronograph so that the form of the wave and its time of transit past each point, are represented graphically. The wave is generated by forcing water by a pump into the tube. Positive waves are thus formed which follow the general laws of undulatory motion. The velocity is proportional to the elasticity of the tube and inversely as the density of the liquid. It diminishes gradually as the wave progresses and increases with the rapidity with which the liquid is added. With a sudden addition of liquid, secondary waves are formed of continually diminishing amplitude. When the tube is closed or narrow at the end, reflected waves are formed. If the walls of the tube are not very extensible, harmonic vibrations are formed superposed on the primary waves. In branching tubes a very complicated combination of waves is formed passing from tube to tube. But in the case of the blood the aorta does not permit the waves to pass from one artery to another. Its own waves are transmitted to the arteries where they are gradually lost, but like an elastic reservoir it absorbs and extinguishes the reflected waves.—*Journ. de Phys.*, iv, 25. E. C. P.

9. *Transparency of Flame and of the Air.*—M. E. ALLARD has presented to the French Academy several memoirs on the absorption of the light of lighthouse lamps. The first memoir relates to the transparency of flame. From one to six concentric wicks are used in lighthouse lamps, having a diameter of from 3 to 13 cms. A comparison of the luminous intensity of the flames shows that the brightness increases a little less rapidly than the consumption of the oil; comparing the intensity with the dimensions of the flame, it appears that the brightness per square centimeter increases, but that per cubic centimeter diminishes with the size of the flame. This difference may be accounted for by assuming that the flame is not perfectly transparent. Three methods were adopted for measuring the absorption, by comparing the light of the edge and side of a flat flame, by reflecting the light a second time through the flame by a mirror, and by viewing the electric light through a large flame. The results lead to the coefficient of ·80 for the absorption per centimeter in thickness.

After having established the theoretical formulas which give the effective brightness of the flame as a function of its volume and coefficient of absorption, it appears that to satisfy the observations we must assume that the specific brightness increases a little with the diameter. Multiplying then the specific brightness by the volume, it appears that the total quantity of light increases much more rapidly than the weight of oil burned; but as the quantity of light absorbed increases still more rapidly, the light increases a little less rapidly than the oil consumed, as experiment shows.

The second memoir relates to the nocturnal transparency of the atmosphere. Observations are made three times every night by the lighthouse-keepers, as to which of the adjacent lights are visible. Combining the results for several years gives the percentage of nights on which each light is seen. The equation of the range of visibility and a graphical construction serve to show for each light in all cases what degree of transparency of the air is needed to render the light visible. A curve may then be constructed with the transparency of the air and the visibility of the lights as coördinates. From this it appears that during half the year the coefficient of transparency per kilometer exceeds ·91 in the Atlantic and ·932 in the Mediterranean. Similar curves give the transparency at different points along the coast, and during the four seasons.

The third memoir treats of the apparent brightness of a light caused by revolving the system of lenses employed with greater or less rapidity. With a certain velocity, a flickering effect is produced, but with an increased speed the light becomes steady with an intensity one or two tenths less than would be obtained by distributing the light uniformly around the horizon.—*Comptes Rendus*, lxxxi, 1096. E. C. P.

10. *Etheric Force of Edison.*—Prof. E. J. HOUSTON, in an article in the January number of the Journal of the Franklin Institute,

concludes from his experiments—as many physicists may have concluded from the published account of the supposed new force—"that all the phenomena noticed by Mr. Edison are explainable by the presence of inverse electrical currents of considerable quantity, but comparatively small intensity, instantaneously produced at the making or breaking of the battery circuit."

II. Geology and Mineralogy.

1. *U. S. Geological and Geographical Survey of the Territories*, F. V. Hayden in charge. Department of the Interior. *Bulletin No.* 5, *Second series.* Washington, Jan. 6, 1876.—This new Bulletin contains the following important papers: A review of the fossil flora of North America, by L. Lesquereux; New fossil plants of the Lignitic formations, and from the Dakota group of the Cretaceous, by L. Lesquereux; Notes on the Lignitic group of Eastern Colorado and Wyoming, by F. V. Hayden; Geology of localities near Cañon city, by S. G. Williams; On *Zapus Hudsonius*, and on the breeding habits, nest and eggs of *Lagopus leucurus* (the white-tailed Ptarmigan), by Dr. Elliott Coues, U. S. A.; List of Hemiptera of the region west of the Mississippi, including those collected during the explorations of 1873, by P. R. Uhler; On the supposed ancient outlet of Great Salt Lake, by A. S. Packard, Jr.

The question as to the age of the Lignitic beds is here discussed anew by Prof. Lesquereux with the presentation of some additional facts. His conclusions remain unchanged. They are as follows.—Above the Lower Cretaceous beds or those of the Dakota group, in the Rocky Mountain region, the first fossil plants met with are the species of the Lignitic formation. This formation is divided into (1) the *Lower Lignitic*, marked by the presence of a profusion of Palms, especially species of *Sabal* (showing a warm, moist climate, like that of Florida, while the Cretaceous plants of the Dakota group indicate one like the present of Ohio) along with species of *Ficus*, *Cinnamomum*, *Magnolia*, *Myrica*, *Quercus*, *Platanus*, *Diospyros*, *Mamnus*, *Viburnum*, etc. (and as yet no *Acer*), and referable to the *Eocene;* (2) the Evanston group, "considered *Upper Eocene* or *Lower Miocene;*" (3) the Carbon Group (more to the eastward, about long. 106½° W.) "or *Middle Miocene*," above which comes (4) the Green River Group, or *Upper Miocene*. The flora of No. 2 includes thus far 90 species, of which a third are known from No: 1; fruits have been found that have been referred to the Palms, but no leaves; there are also in it dentate and serrate leaves of *Salix*, *Betula*, *Alnus* and *Acer*. The flora of the Carbon Group is "positively Miocene;" 18 species, or nearly a third of all, are identical with European Miocene plants, and 13 with Arctic Miocene, while a few occur also in the Lower Lignitic (No. 1.)

Among 23 species from the Point of Rocks, referred to No. 1, or the Lower Lignitic, two occur also in beds to the north of the

United States boundary, called Tertiary by G. M. Dawson, seven are identical with, and five related to, species of the Lower Miocene of Europe, two occur in the Arctic Miocene, three are found also at Golden, eight at Black Butte, and two have some analogy with Cretaceous types.

Hayden, in his remarks on the Lignitic beds, observes that there are lignitic or coal beds in both the Cretaceous and Tertiary formations of the Rocky Mountain region; but that, so far as Eastern Colorado is concerned, from Raton Hills to Cheyenne, the lignitic beds are not associated with marine deposits, but those of brackish water or freshwater origin, and that these are not Cretaceous, but of Eocene age, the evidence from the plants pointing, according to Lesquereux, to this conclusion. He further states that in Southern and Southwestern Colorado, as shown by Mr. Holmes and Dr. Endlich of the expedition, and also other authorities, heavy beds of coal occur all through the Cretaceous. Hence, taking, he says, the whole Rocky Mountain region into view, there is a *Lower Lignitic* group which is *marine* and *Cretaceous;* above this, the *Middle Lignitic*, *brackish water* in origin, which is *Lower Tertiary* or *transitional;* and next the *Upper Lignitic*, *freshwater* in origin, which is unquestionably *Tertiary.* The coal deposits of Carbon are included in the third of these divisions, and those of Bear River and Coalville in the first. Dr. Hayden observes that Dinosaurian remains occur even in the freshwater or upper division, as noticed by Cope and Marsh; but that the species are not identical with any known Cretaceous species. The Green River beds overlie the Lignitic beds unconformably.

The difference between Prof. Lesquereux's view and those of Dr. Hayden appears to be this: Lesquereux makes the Eocene to include the Bear River and Coalville beds, and all the older Lignetic beds the fossil plants of which he has examined (including those even of Vancouver Island, where Ammonites and Baculites occur in beds *overlying* the coal); while Dr. Hayden admits that there is a series of Cretaceous coal beds, that the Bear River and Coalville deposits are included in it, and that these Cretaceous strata are distinguished by being mainly marine and containing Cretaceous fossils.

Between the views of Prof. Lesquereux and those of the zoological paleontologists the divergence is great. For while he makes the Green River beds (containing remains of fossil plants and fishes) "Upper Miocene," and the Carbon beds "Middle Miocene," Leidy, Cope, and Marsh hold that even higher strata, namely, those overlying the Green River beds conformably (having an estimated thickness of five or six thousand feet) and which contain the oldest Mammalian remains of that part of the continent, are *Eocene;* and that the underlying Green River beds are *Lower Eocene;* and further that all the Liginitic beds. that are older than the Green River beds, are *Cretaceous*, since they contain Dinosaurian remains, and some of them other Cretaceous fossils.

Thus widely the best authorities differ; partly because European tests of geological age are not always good for use in America, and partly, also, from deficient American testimony. We are disposed, with the present light, to argue the case as follows:

First. It is highly improbable that the type of Dinosaurs should have been represented all through the Eocene and into the Miocene—as must be true if Lesquereux's conclusions are right.

Secondly. Mammalian fossils are a far safer criterion of geological age than fossil plants—since the changes in the species of mammals through the successive eras of the Tertiary are vastly greater than in those of plants; and as the mammals of the beds next above the Green River beds are strongly Eocene in their characteristics—as attested to by Leidy, Marsh and Cope—it is exceedingly improbable that the beds affording the fossil mammals should be Upper Miocene, or Miocene at all.

Thirdly. If the beds containing these mammalian remains, together with the *underlying* Green River beds, are *Eocene*, then the Evanston beds, and the Carbon beds also if older than the Green River, are either earlier Eocene or Cretaceous. It follows also, *fourthly*, that the "Miocene" features of the plants of the Liginitic beds are not due to the plants being of Miocene age; and hence, *fifthly*, that the diversities in the cotemporaneous Tertiary flora of Europe and North America are so great that little use can be made of the facts from one continent for fixing the chronology of beds in the other.

It is probable, that part of the diversity in vegetation of different localities was owing to local physical conditions, and to migrations consequent on changes of climate with the progress of time during the Lignitic era; and that much of the diversity between America and Europe was due, as suggested by Lesquereux, to many of the Miocene plants of Europe having previously existed as Eocene or Cretaceous plants in America.

If the fossil plants are an uncertain test of geological age, so may it be also, to some extent, with the fossils animals, when characteristic species are sparingly present. Even the existence of Dinosaurian remains in the later Lignitic, and of Inocerami where Ammonites and Baculites are absent, may not prove absolutely that the beds containing them are Cretaceous rather than Lower Eocene, since some animals species may have survived the changes separating the two eras, as has happened in the case of other successive eras.

In the paper, *on the former outlet of Great Salt Lake*, Dr. Packard points out that General Connor has found, by his railroad surveys, that the lowest part of the including rim of hills is at Skull Valley, west of the lake, and that the height there is "somewhat over 100 feet above the present level of the lake." He adds that the river-bed has been traced southward over 100 miles to the Sevier Lake Valley, passing west of Sevier Lake. It is probable, further, that the river joined the Colorado near the confluence of the Muddy River and Rio Virgen; but it may have had an

independent outlet into the Dry-Lake Basin north of east of San Diego, a region seventy feet below the present sea-level. Dr. Packard hence concludes that the lake was once fresh, and that it has become salt by evaporation and contributions from salt springs and the soil. J. D. D.

2. *Drift formation and Gold in Missouri;* by G. C. BROADHEAD.—The drift of Missouri is confined to the part of the State north of the Missouri. The upper beds are chiefly sand with some small pebbles and a little clay; lower down are large bowlders, and at base are blue clays. In Sullivan Co., and the western part of Adair the depth is 50 to 60 feet; in Davies Co., 40 to 80 feet; in northeastern Adair, over 100 feet; in Knox, 200 feet; in Putnam, over 70. In Illinois, in Moultrie Co., the depth is over 200 feet, as shown by wells, and in Decatur Co., over 90 feet. Gold has been found in Missouri, in Chariton, Linn, Adair, Putnam, Sullivan and Mercer Counties. It is in very small grains, the largest particles, from Adair Co., are not larger than a grain of wheat.—*Mines, Metals and Arts, St. Louis, Dec.* 9.

3. *Glacial striæ north of Lake Ontario, in the Ontario district, Western Canada.*—Prof. CHAPMAN, in a paper on the Geology of Ontario (Canadian Journ., xiv, 580, Dec., 1875) states that the limestone strata beneath the glacial and post-glacial deposits (which cover a large part of the Lake Ontario district) are found to be generally striated, and that the striæ run commonly in a *southwest* direction. The direction proves that the slope of the upper surface of the glacier in that region was from the northeast to the southwest; or that the greatest height of the ice surface lay somewhere to the northeast of that district.

4. *New Fucoid from the Water-lime Group (Lower Helderberg) of Western New York.*- Messrs. A. R. GROTE and W. H. PITT have described a species of *Buthotrephis*, from the Water-lime, which they call *B. Lesquereuxi*. The stem, originally cylindrical, branches from the base; and the branches are simple or sparingly dichotomous, smooth, 13 to 14 cm. long, 3 to 4 mm. thick, but gradually widening to nearly 1 cm. at the obtuse or round-truncate point.—*Bull. Buffalo Soc. Nat. Sci.*, 1876 (January), p. 88.

5. *Petrifaction.*—CHEVREUL, in a paper before the French Academy, sustains the view that the petrifaction of an organic substance, as wood, comprises two epochs: the *first* is that of the filling of all the interstices and pores of the solid body by a solution of the mineral material through capillary action, to fix it chemically by affinity upon the solid portion—producing a petrifaction which has the figure of the interstices and pores; and the *second* includes the time of the total disappearance of the organic matter itself and its replacement by the mineral material, the result of this action having the actual form of the organic matter.

Daubrée, after the reading of M. Chevreul's paper, mentioned facts from the hot baths of Bourbonne-les-Bains confirming his conclusions. He stated that wood occurs in the waters in all states of change by the petrifying agent, carbonate of lime. In

one specimen a portion was nearly 97 per cent carbonate of lime, all the organic tissues but 3·1 p. c. having disappeared; while in another portion, less changed, only the interstices and cellules were filled by the carbonate of lime. In one specimen the wood nearest the bark and the bark contained no carbonate of lime, as was easily proved by an acid.

6. *Green Mountains.*—On page 498 of the last volume of this Journal (Supplementary December number), a note is inserted correcting the blunders which have long circulated in Geographies, Gazetteers, Encyclopedias, and New England Guide-books, as to the Green and White Mountains terminating in trap ridges—called West and East Rocks—in the vicinity of New Haven; the fact being that East Rock is but a short appendage (half a mile long) to the system of trap dikes of the Connecticut valley, and West Rock, a southern portion of the same system. Prof. O. P. Hubbard has informed the writer that this extraordinary error in New England Geography has the following forms in "The Imperial Gazetteer" published by Blackie & Son at Glasgow, Edinburgh and London, in 1855. Under NEW HAVEN, "Surrounded on three sides by spurs of the Green Mountains." Under GREEN MOUNTAINS, "A mountain range commencing near New Haven, Connecticut." Under CONNECTICUT, "Some of its mountains, particularly the Green Mountain range," etc.

The Green Mountains consist of metamorphic rocks and are not younger than Silurian. They have their greatest height in Vermont, and there received the name. The mountain system extends south through *western* Massachusetts and *western* Connecticut, and the whole is rightly called the Green Mountain chain. But the trap ridges of the Connecticut valley, belong to the valley, and are of Jurassic origin. J. D. D.

7. *Geology of New Caledonia.*—The formations of New Caledonia, below the Quarternary, according to M. Garnier, include the Lower Neocomian (Lower Cretaceous); Upper Lias (containing *Nucula Hammeri*); Lower Lias (containing *Ostrea sublamellosa*, &c.); Upper Trias (containing *Halobia Lomelli*); Lower Trias (with *Avicula Richmondiana*); Upper Devonian and Upper Silurian; besides also crystallized rocks. Among the last mentioned are mica schist and argillaceous slate with quartz veins, some of them auriferous, amphibolite, talcose slate and serpentine, with crystalline limestone. At Koé and Karigou the coal is anthracitic, partly graphitic; and at the latter place it is said to have been rendered anthracitic by a dike of euryte porphyry. To the northwest of Mont d'Or it is bituminous, but impure.

The serpentine or magnesian rocks cover a large part of the island. The serpentine contains bronzite or diallage, chromic iron, magnetite, "hydrosilicate of magnesia," and is traversed by "veins" of chrysolite. It passes into white argillaceous [probably hydro-mica] schists, and these are intimately associated with the serpentinous schists [facts which prove that the serpentine is not, as Garnier states, igneous, but, like most serpentine rocks, meta-

morphic]. Chromic iron is abundant on Mont d'Or; an analysis of it afforded

$$\mathrm{\bar{F}e}\ 34{\cdot}00,\ \mathrm{\bar{C}r}\ 61{\cdot}33,\ \mathrm{\bar{A}l}\ 0{\cdot}11,\ \mathrm{\dot{M}g}\ 0{\cdot}01,\ \mathrm{\ddot{S}i}\ 4{\cdot}63=100{\cdot}08.$$

Ores of nickel occur in the serpentine, and are of workable value. The only ore mentioned is a greenish pimelite-like silicate, a variety of which has been named *garnierite.*

M. Garnier, who is in charge of the New Caledonia mines under the French Government, has published on the Geology of New Caledonia in the *Bulletin of the Geological Society of France*, II, xxiv, 438, 1866, and in the *Annales des Mines*, VI, xii, 1867; and later communications have appeared in the *Moniteur de la Nouvelle Calédonie.—Abstract of part of Address of Rev. W. B. Clarke before the Royal Society of New South Wales, at the Anniversary meeting in May*, 1875.

8. *Achrematite, a new mineral;* by Prof. J. W. MALLET.—This mineral is in general compact, with indistinct crystalline structure; an examination in polarized light suggested that it might belong to either the hexagonal or tetragonal systems. Color, a sort of liver-brown, though under the microscope the pure grains appear pale sulphur-yellow. Streak, pale cinnamon-brown. Luster, between resinous and adamantine. Translucent on thin edges, in minute grains nearly transparent. G.= 5·965 on a solid fragment, but = 6·178 with a fine powder. H.= 3–4. Fracture uneven; brittle. A mean of three analyses gave, after deducting impurities,

$$\tfrac{3}{3})\mathrm{As^2O^5},\ 18{\cdot}25,\ \mathrm{MoO^3},\ 5{\cdot}01,\ \mathrm{Cl}\ 2{\cdot}15,\ \mathrm{Pb}\ 6{\cdot}28,\ \mathrm{PbO}\ 68{\cdot}31=100{\cdot}00,$$

which makes *achrematite* a molybdo-arsenate of lead. Several reasons are given for the conclusion reached that the arsenate and molybdate of lead are in chemical combination, and not mechanically mixed. The name is derived from ἀχρήματος, in allusion to the fact that it contains no silver as was alleged. Locality, the mine of Guanaceré, State of Chihuahua, Mexico.—*J. Chem. Soc.*, II, xiii, 1141, Nov., 1875. E. S. D.

9. *Schraufite*, a new fossil resin from Bukowina described by v. Schröckeringer. It occurs in rounded masses imbedded in a bed of slatey sandstone. Its hardness is 2–2·8; specific gravity 1–1·2; fracture conchoidal; color hyacinth-red. It is decomposed with the evolution of gas at a temperature of 326° C. Its composition, according to Dietrich is $C^{11}H^{16}O^2$. It is named after Professor Schrauf of Vienna.—*Verh. G. Reichs.*, May, 1875, p. 134. E. S. D.

10. *Identity of Seebachite with Phacolite;* v. RATH.—The zeolite from Richmond, Victoria, described by Ulrich and later made identical with herschelite by von Lang, was made a new species by Bauer, under the name of seebachite (Dana's Min., Appendix II, p. 50). A recent examination of the mineral, upon some good crystals, by vom Rath, has proved that the mineral called seebachite is not orthorhombic, as claimed by von Lang, but rhombohedral, and that it is really indentical with phacolite, a variety of chabazite.—*Ber. Ak., Berlin*, 1875, 523. E. S. D.

11. *A new species of Dalmania from Port Jervis, New York.*—Dr. S. T. Barrett, of Port Jervis, has recently described a new species of Dalmania from the Lower Helderberg of that vicinity, and named it *D. dentata.* A description by him, accompanied with a plate, will appear in the next number of this Journal.

J. D. D.

III. Botany and Zoology.

1. *Naudin on the Nature of Heredity and Variability in Plants.*—Why is it the nature and essence of species to breed true, and why do species sometimes vary? In other words, why is offspring like parent, and when unlike in certain particulars, what is the cause and origin of the difference? We commonly and properly enough take these two associated yet opposed facts as first principles. But it is equally proper and legitimate to enquire after the cause of them.

M. Naudin, a good many years ago, took up the study of hybrid plants, and followed up, for a series of generations, the course of life of certain self-fertile ones, notably of *Datura.* We gave at the time an abstract of his observations of the manner in which the characters of two closely related common species, *D. Stramonium* and *D. Tatula*, were mixed, and in which the characters of the two began to separate in the close-bred progeny of the next generation, ending in a complete division of the amalgamated forms into those of the two constituent species after a few generations.

The *Comptes Rendus* of Sept. 27th and Oct. 4th, 1875, contain an abstract of a paper communicated by M. Naudin to the French Académie des Sciences, of which the text was suggested by a hybrid between the wild *Lactuca virosa* and a variety of *L. sativa*, the common Lettuce. The hybrid was an accidental one: its seeds were fully fertile; a great number of young plants were raised from them, of which twenty were preserved for full development and study. Like other hybrids the original showed no character which was not evidently derived from the two parents; and, fertilized by its own pollen, the offspring all agreed in this respect, although they varied exceedingly among themselves in the division of the parental heritage, no two being quite alike. This exceeding vacillation between the two parental forms but not overpassing the limits on either hand,—which Naudin finds to be the common characteristic of fertile hybrids, close-bred — he names disordered variation (*variation désordonnée*). His explanation is, that the hybrid is a piece of living mosaic, that two specific natures are at strife in it; in the progeny each endeavors to reclaim its own, like seeks like; whence in the course of a very few generations (as he first showed in *Datura*), a segregation takes place, part of the progeny reverting completely to one ancestral type, part to the other. What Naudin now insists upon is that out of all this disturbance comes nothing new; that there is here no variation beyond the line of inheritance; and therefore from crossing no possible development of species.

To this proposition we accede, so far as respects the direct consequence of crossing. To fill up the interval more or less between two forms or species with intermediate patterns may tend to the fusion or confusion of the two, but not to the origination of new forms or species. Although Naudin's own experiments lead him to deny all tendency to variation overpassing these limits, we do not forget that his countryman, the late M. Vilmorin,—working in a different way and with another object,—arrived at a different conclusion. He succeeded, as we understand, in originating floricultural novelties from species which refused to vary *per se*, by making a cross,—not to infuse the character of the male parent, for he fertilized the progeny with the pollen of the female parent, and thus early bred out the other blood, but to induce variation, which, once initiated in the internal disorder consequent upon the crossing, was apt to proceed, or might be led on by selection, to great lengths, according to Vilmorin. The variations in question, being mainly such as are sought in floriculture, may not have passed the line laid down by Naudin, or actually have introduced new features. But such plants would surely have no exemption from the ordinary liability to variation. If other plants vary, in the sense of producing something new, so may these.

This brings us to another inference which Naudin draws. Having observed that his hybrids in their manifold variation exhibited nothing which was not derivable from their immediate ancestry, he directly (and in our opinion too confidently) concludes that all variation is atavism,—that when real variations are set up in ordinary species, this is not an origination but a reversion, a breaking out of some old ancestral character, a particular and long deferred instance of this *variation désordonnée*, which would thus appear to be the only kind of variation. This view has been presented before, but not, perhaps, so broadly. Adducing some theoretical considerations in its favor—to which we may revert—and some sound reasons against the view that variation is caused by external influences, he declares it "infinitely more probable that variation of species properly so called is due to ancestral influences rather than to accidental actions." We might think so if these two categories were exhaustive, and external conditions must be supposed to act immediately, as the cause rather than the occasion of variation. But the supposition that "accidental actions," whatever they may be, and external influences of every sort do not produce but educe and conduct variation—which is our idea of what natural selection means—avoids the force of Naudin's arguments.

Moreover Naudin's view, regarded as an hypothesis for explaining variation, leaves the problem just where it finds it. To explain the occurrence of present and actual variations, hypothetical ones like those of a former time are assumed; the present diversity implies not only equal but the very same anterior diversity, and so on backwards. Or rather it demands a much greater diversity at the outset than now; for these aberrant forms are the rare exception, and if due to atavism they imply the loss of the many and the inci-

dental reappearance of the few. Else they would be the rule instead of the exception, and atavism would be simply heredity. This comes to the view which Mr. Agassiz strongly maintained, that really there are no varieties,—meaning, we understand, that all the forms are aboriginal, except the transient ones evidently due to circumstances.

That some variation is atavism is clear enough. This is the natural explanation of the appearance of characters wanting in the immediate parents but known in their ancestors or presumed ancestors. But the assumption of hypothetical ancestors to account for variation generally is quite another thing. Besides its inutility as an explanation, to which we have adverted, its improbability as an hypothesis is set in a strong light by Naudin's own forcible conception of the nature of heredity. What is heredity? he asks. In other words, what keeps species so true, offspring like parent, through the long line of generations? He illustrates hereditary force by comparing its action with that of physical force, in which the movement from one state of equilibrium to another is always that in which there is least resistance. From which it follows that when it has once begun to proceed in a certain course, its tendency to continue in that direction increases, because it facilitates its way as it overcomes obstacles. In other words this line becomes fixed by habit; *vires acquirit eundo;* the stream deepens its bed by flowing; and the more remote the commencement of a certain course, the more fixed its direction, and the greater its power of overcoming opposition. The species is kept true in its course by the sum of the heredities which press each individual forward in its actual direction. So that, as Naudin remarks, if we could calculate the energy with which millions of ancestors tend to impel the living representatives of the line onward in the same direction, we should better apprehend the persistence of species, and feel the great improbability that the stream will ever escape from its ancient and well-worn bed, and strike into new courses.

Now, in the first place, the more lively the conception we thus form of the invariability of species, through a happy metaphorical illustration of it, the more unlikely does it appear that early characters, long lost in the flow, should re-appear through atavism as varieties. To continue the simile, the more impetuous the stream, the less the possibility of its turning back upon itself, and resuming old characteristics. The eddies of atavism (the resumption of dropped characters) are not likely to extend back very far; and it seems gratuitous to have recourse to them in explanation of new forms. Moreover, although the stream has made its bed and lies in it, not escaping from its own valley, it is flexible enough to obstacles, is ever changing its particular course as it flows, and may by its own action send off here and there a bayou (variety) or branch into a delta of channels (derivative species).

Like Agassiz, Naudin conceives of species as originating with a large number of individuals of the same structure, and of which

numerous reciprocal crosses have determined the direction of the line in which their posterity have evolved. But he mantains that these individuals, and all existing species, had a common origin in a "proto-organism;" and that the various lines of descent acquired fixity into species only as they acquired sexuality. If we rightly apprehend it, Naudin's idea of the purport of sexual reproduction (as contrasted with that by buds) is, to give fixity to species. Our idea is a different one, both as to the essential meaning of sexuality, and as to its operation in respect to fixity. His conception may be tested by enquiring which are the more variable or sportive, seedlings or plants propagated from buds. This we suppose can be answered in only one way.

M. Naudin is a veteran and excellent investigator; and nothing which he writes is to be slighted. We have frankly set down our impressions upon a first perusal of his important communication; but are ready to revise them, if need be, upon more deliberate consideration. A. G.

2. *First Forms in Vegetation;* by the Rev. Hugh Macmillan, LL.D., F.R.S.E. With numerous illustrations. Second edition, corrected and enlarged. London: Macmillan & Co. 1874. pp. 438, 18mo.—The first edition under a somewhat different title, was published in 1861. In the present volume it is brought up to the time, and we suppose much amplified. As it stands it forms an excellent popular introduction, of the readable sort, to lower Cryptogamic botany, from Mosses (and even Club-mosses) to Fungi. The materials of its chapters were first used for popular lectures, and this primary form and use gives its character to this re-written and now extended volume. The author wished to recast it in a systematic mold, but was deterred not only by the labor required, but by the doubt whether it were worth the while. We fancy it is better as it stands, and more likely to fulfill its purpose, which is "to kindle the sympathy and awaken the interest of the reader in a department of nature with which few, owing to the technical phraseology of botanical works, are familiar." The book is full of information, possibly too full for the object in view, except that it cannot be amiss to gratify as well as awaken interest in the lower forms of vegetation by referring to as large a number as is practicable. The spirit in which the subject is handled is indicated by the motto: "*Deus magnus in magnis, maximus in minimis;*" and the sermonizings, being apposite, we have no right to intimate that they are too many and too long. There are good indexes of scientific and of popular names. It is not often that an amateur-botanist writes a book of this kind which is more free from serious errors or misunderstandings. But the statement that the antherozoids of mosses, although "furnished with cilia, like animalcules," yet "their motion is simply a hygrometical action, like that of the teeth which fringe the mouth of the capsule," must be one which unaccountably escaped revision, even in the edition of 1861. So also the suggestion that sexual reproduction may be gradually dispensed with in the lower plants and

animals, which is in fact corrected in the latter part of the volume. In referring to Prof. Tuckerman, we hope it may be long before he must be designated as "the *late* distinguished American lichenologist." The "conjecture" which "*may* be hazarded" that the Red Sea "acquired its denomination from the prevalence of this red alga [*Trichodesmium erythræum*] in its waters," *was* hazarded by Ehrenberg, if we mistake not, at the time of its discovery. The late Dr. M. A. Curtis, our American mycologist, informed Mr. Berkeley, as we remember, that he and his neighbors whom he instructed, procured no small supply of excellent food from the edible Fungi, which grew around his home, in the center of North Carolina, so abundantly that he opined he might have supported a regiment on them. This, we suppose, is the whole foundation for the extraordinary statement that, "During the latter part of the American war, when meat was scarce and dear, fungi, which grow in immense profusion and variety in America, formed the principal food of the Southern army." A. G.

3. *Seeds that float in water* have a certain interest in connection with questions about dissemination. Many ranked as such are fruits, botanically speaking, with spongy or cellular pericarp, or with some air-space between the pericarp and the seed itself. But there are a considerable number of true seeds with specific gravity less than that of water, some as low as 0·75. Van Tieghem (Ann. Sci. Nat., ser. 6, i, 383) finds that this is due to different causes. More commonly the seed owes its lightness to its coats, either by a separation in drying between the two, or between the inner and the kernel, leaving an air-space, or by a loose cellular structure of the coat. Sometimes, as in castor-oil seeds, the integument is heavier than water, but the kernel is so much lighter as to float the seed. This comes from a separation of the two cotyledons during the natural desiccation, leaving a considerable cavity filled with air. This is strikingly the case in the large, flat, and very dense-coated seeds of *Entada scandens*, which are well known to have been wafted across the Atlantic from the West Indies to Northern Europe and left in a condition fit for germination; while in those of *Guilandina Bonduc*, which have been known to accompany the former, the air is interposed between the embryo and the bony coat. The embryo itself, in all such cases, is heavier than water. But to this rule Van Tieghem now brings to light a few exceptions, and these in leguminous seeds. In those of *Erythrina crista-galli*, the specific gravity of the whole seed is 0·91, that of the embryo itself 0·87. Those of our *Apios tuberosa* are a little lighter, of our *Wisturia frutescens* a little heavier than this, but still lighter than water; and various common leguminous seeds, although heavier than water, are much lighter than would be supposed. This proves to be owing to a very loose and open structure of the *parenchyma* of the inner or upper side of the cotyledons (that which answers to the upper face of the leaf), leaving abundant intercellular spaces and passages, filled with air, which renders this spongy stratum light enough in certain cases to float the otherwise heavy seeds. A. G.

4. *Use of the hygrometic twisting of the tail to the carpels of Erodium.*—We have no indigenous or common *Erodium* this side of Texas; but there and in California one or two species are common. The narrow carpel is pointed at base; the long awn or style in drying bends at right angles with the carpel, and twists in many turns, depending on the amount of dryness, and untwists in a moister air or when wet. We had wondered that no one seemed to have given an account of the way in which this mechanism acts so as to bury the seed in the ground. Dispersed by the wind over the loose or sandy soil which these species prefer, the seed-bearing end being the heavier lies next to the ground, and is the comparatively fixed point, around which the long awn makes circular sweeps, whether in twisting or untwisting. This gives a rotary movement to the carpel, fixes the sharp end in the soil, and, whether twisting or untwisting, causes it to bore into and bury itself in the ground. It is the same with the grain and awn of Stipa. As to *Erodium*, we have just found that this is described by G. Roux, in the Annals of the Botanical Society of Lyons, France. He adds that, when in this way thus interred, the moisture of the soil soon destroys the epidermis and this allows the long beak to detach itself at its articulation with the style, leaving it planted in good condition quietly to germinate. M. Roux enters into details about the effect of light, heat, chloroform, etc., upon this movement, which seem to us superfluous and wide of the mark. A. G.

5. *The Lemurs not related to the Monkeys.*—In the genealogical tables of Hæckel, the Lemurs are made the point of divergence of lines leading to the Insectivores and Carnivores on one side and to the Rodents and the Monkeys on the other. MM. Grandidier and Alph. Milne Edwards, in their recent work on the Mammals of Madagascar, show that the Lemurs have striking peculiarities in the conformation of the allantois and placenta, and not the close relation to the monkeys generally supposed. By injecting the capillary vessels of the placenta and uterus they have studied the vascular relations of the fetus with the mother, and established thus profound differences between the two types, which begin even in their intro-uterine life.—*L'Institut*, Dec. 29.

6. *Fauna of the Greenland Seas.*—The Fauna of the Greenland Seas, according to results obtained by the "Valorous" (on its return from Disco), agrees with its land flora in being mainly Norwegian, there being (with the exception of the Echinoderms) an absence of many North American forms, which, as it appears, have not been found east of the meridian of Cape Chidley in Labrador. A *Campanularia* was obtained identical with one found by Mr. Eaton, of the British Transit-of-Venus Expedition, at Kerguelen's Island; also, in the towing-net, a sponge-like diatom, *Synedra Jeffreysi* Dickie, with living Globigerinæ entangled in the connecting protoplasmic matter of its frustules. The deep waters of Davis Straits afforded a mollusk which was long since found fossil in the newer Tertiary of Sicily, and was supposed to be extinct.—*Proc. Roy. Soc.*, No. 164, p. 78.

IV. Astronomy.

1. *New Planet.*—The discovery of another planet by Herr Knorre was announced by telegram to Prof. Henry, Jan. 11th.

2. *Harvard Observatory Engravings.*—The last instalments of the engravings from Harvard College Observatory have been distributed to the subscribers. Instead of 30 plates as promised, 35 have been issued. These later plates represent two star clusters, six views of nebulæ, four views of Donati's comet, and three of Coggia's comet. A letter press description of the engravings is, we understand, to be soon issued.

3. *The Uranian and Neptunian Systems investigated with the 26-inch Equatorial of the U. S. N. Observatory;* by Professor Newcomb. Appendix I of the Wash. Obs. for 1873, p. 74.—This paper is the first extended contribution of results obtained by the large Washington telescope. It is a discussion of the observations made between November, 1873, and May, 1875, upon the four satellites of Uranus, and the satellite of Neptune. It closes with tables of the motions of the satellites, for a portion of which credit is given to Prof. Holden.

Prof. Newcomb obtains $\frac{1}{22600}$ as the most probable value of the mass of Uranus, with an estimated probable error of the denominator of 100. He finds no evidence of any mutual inclination of the orbits of the four satellites and but slight evidence of any real eccentricity. The following are the mean distances from Uranus at the mean distance of Uranus from the sun: Ariel, $13''\cdot78$; Umbriel, $19''\cdot20$; Titania, $31''\cdot48$; and Oberon, $42''\cdot10$. The periods of revolution are $2^d\cdot520378$; $4^d\cdot144537$; $8^d\cdot705897$, and $13^d\cdot463269$. The former two are not changed from the determinations of Lassell and Marth. The inclination of the plane to the ecliptic is $97^\circ\cdot85-0\cdot013T$, counting from the epoch 1850.

The only means of estimating the masses of the satellites is a comparison of their light with that of the planet. From this Prof. Newcomb infers that they probably do not exceed $\frac{1}{15000}$ of the planet. If so their mutual action, and the sun's action on them, are of no importance. Prof. Newcomb adds: "I think I may say, with considerable certainty, that there is no satellite within 2′ of the planet, and outside of Oberon, having one-third the brilliancy of the latter, and therefore that none of Sir William Herschel's supposed outer satellites can have any real existence. The distances of the four known satellites increase in so regular a way that it can hardly be supposed that any others exist between them. Of what may be inside of Ariel, it is impossible to speak with certainty, since, in the state of atmosphere which prevails during our winter, all the satellites would disappear at 10″ distance from the planet. The planet always presented itself of a sea-green color. No variations of tint were ever seen. Markings on the planet were not especially looked for, but had any been visible they could hardly have escaped notice."

For the mass of Neptune the value $\frac{1}{19380}$ is obtained. In the

perturbations of Uranus, Prof. Newcomb used $\frac{1}{19700}$. The distance of the satellite from Neptune is 16·275, its daily motion 61°·25679, its inclination to the ecliptic 145°12; and the orbit so far as observations show is circular.

No trace of a second satellite of Neptune has ever been seen, though it was several times carefully looked for under the finest atmospheric conditions.

V. Miscellaneous Scientific Intelligence.

1. *Report on the Compressive Strength, Specific Gravity, and Ratio of Absorption of Building Stones in the United States;* by Q. A. Gillmore. 38 pp. 8vo, with two plates. 1876. Official Report to the Chief of Engineers, U. S. Army. (D. Van Nostrand.)—This report contains the results of a very careful series of experiments on various building stones of the country. The method of experimenting in the crushing is particularly described, and the results as to crushing-strength with the cubes of stone in different positions, and between wood, lead and leather cushions, etc., are given in detail. The tables contain entries of 99 experiments on granites, 43 on limestones, 12 on marbles, and 62 on sandstones.

2. *Science and Art Department of the Committee of Council on Education, South Kensington.*—The Loan Exhibition of Scientific Apparatus will open on the 1st of April, 1876, and remain open until the end of September. It will consist of instruments and apparatus employed for research and other scientific purposes for teaching, and for illustration of the progress of science and its applications to the arts. Models, drawings, and photographs will be admissible where originals cannot be sent. Forms on which to enter descriptions of objects offered for exhibition may be obtained on application to the Director of the South Kensington Museum, London, S.W., and these forms should be filled up and returned as soon as possible, so that exhibitors may receive early intimation as to the admissibility of the objects they propose to send. The Science and Art Department defrays the cost of carriage, but, while using all possible care, is not responsible for loss or damage. The circular issued expresses the hope that institutions or individuals having instruments of historic interest will be good enough to lend them. The instruments and apparatus desired are of all important kinds connected with the subjects of arithmetic, geometry, measurement, kinematics, statics, dynamics, molecular physics, sound, light, heat, magnetism, electricity, astronomy, applied mechanics, chemistry, meteorology, geography, geology and mining, mineralogy, crystallography, biology, (microscopes, &c.)

3. *Works on the Paleontology of the Rocky Mountain Surveys in progress.*—The first four months of this year will witness the publication of an unusually large number of works on the invertebrate paleontology of the great Rocky Mountain and adjacent regions, some of which have been delayed several years. The following are either partly or wholly in type and will soon be published.

(1.) Paleontology of the Upper Missouri, by F. B. Meek; a quarto volume of between 500 and 600 pages of text and 45 lithographic plates of illustrations. It is confined to fossils of the Cretaceous and Tertiary periods, and is a very exhaustive treatise.

(2.) Paleontology of Clarence King's Geological survey of the 40th parallel, quarto, by F. B. Meek. This Report comprises about 150 pages of text and 17 lithographic plates. It embraces fossils of Lower Silurian, Devonian and Carboniferous ages and of the Triassic, Jurassic, Cretaceous and Tertiary periods.

(3.) Paleontology of the Report of Capt. Simpson's expedition; quarto, by F. B. Meek. Comprises about 100 pages of text and 5 lithograph plates. Cretaceous and Tertiary periods.

(4.) Paleontology of the Report of Capt. McComb's expedition; quarto. Cretaceous fossils, by F. B. Meek and Carboniferous fossils by J. S. Newberry.

(5.) Paleontology of parts of Vancouver's Island and Washington Territory, by F. B. Meek. About 100 pages octavo, and 6 plates.

(6.) Invertebrate Paleontology of Lieut. Wheeler's Explorations and Surveys west of the 100th meridian; quarto, by C. A. White. About 220 pages of text and 21 lithographic plates. This report embraces fossils of the Primordial, Canadian, Trenton, Subcarboniferous, Carboniferous, Jurassic, Cretaceous and Tertiary periods.

(7.) Preliminary Report on the Invertebrate Paleontology of the Plateau Province, by C. A. White, quarto; about 50 pages. It will embrace fossils of the Carboniferous, Jurassic, Cretaceous and Tertiary periods. Among other important facts it will contain an announcement of the existence of open-sea marine deposits at Bijou Basin, forty miles east of Denver, Colorado; the fossils of the deposit belonging to the genera *Venus*, *Mesodesma*, *Dentalium*, *Phorus* and an *Oculina* undistinguishable from the species common in the Vicksburg Tertiary beds. This is to form a part of a report nearly ready for publication by Professor J. W. Powell, Chief of the Second Division of the Geological Surveys of the Interior Department. C. A. W.

4. *Geological Map of the 40th Parallel Survey.*—Map number II, by CLARENCE KING, Geologist in Charge, and S. F. EMMONS, Assistant Geologist, has been issued as authors proofs, dated Nov. 15th, 1875.—This map, which covers the Green River Basin and most of the Uinta Mountains, a region of great geological interest, will be regarded as a model, as it has not been surpassed in accuracy and artistic execution by any similar work in this country. It is in two sheets, each 24 by 33 inches, and is on a scale of four miles to the square inch. It is the first of the series issued, and will be noticed more fully when the other parts are published.

5. *Depth of the North Pacific.*—The soundings by the "Challenger" in the North Pacific as given in the Proceedings of the Royal Society, No. 164, afford the following results:

Along a line from California to the Sandwich Islands the mean depth is 15,180 feet; and the least depth, about half way, near 13,000 feet.

Along a line from the Sandwich Islands to the Bonin Islands, south of Japan, the shoalest part is near 177° east longitude, where the depth is 6,650 feet.

Between longitude 177° E. and the Sandwich Islands the mean depth is about 16,000 feet; maximum depth, 19,140 feet; depth within eighty miles of the Sandwich Islands south of Kauai, over 14,000 feet.

Between longitude 177° E. and the Bonin Islands, the mean depth is nearly 16,900 feet; maximum, 19,720 feet.

On a line running north from the Sandwich Islands, between latitude 22° and 38° N., mean depth about 17,000 feet; and between this northern point and Japan, mean depth about 16,000 feet; maximum, 22,800 feet, within 180 miles of Japan, and minimum near 178° E., 12,300 feet.

The region of the minimum on this last route is nearly north of that on the route from the Sandwich Islands to the Bonin Islands; but the depth is greater, being 12,300 feet against 6,650 feet on the latter.

The mean depth for the north Pacific as deduced from all the deep-sea soundings is about 16,200 feet.

6. *An Iceland chain of elevations in the North Atlantic.*—The ship "Valorous," which took out stores to Disco for the British Polar Expedition, made deep-sea soundings on its return. Among the discoveries, as mentioned in a Report to the Royal Society (Proc. No. 164), was an elevation of the ocean's bottom in latitude 56° N. and longitude 34° 42′ W., to the southwest of Iceland, over which soundings of 690 fathoms were obtained between depths of 1450 fathoms on one side and 1230 on the other. Directly between this spot and Iceland, in latitude 59° 40′ N., and 29° 30′ W., H. M. S. "Bull-dog" found a similar elevation. In about the same direction, northeast of Iceland, there lies the island of Jan Mayen. This line is parallel to the Greenland coast, and the whole length thus indicated is over 1300 miles. Iceland and Jan Mayen being volcanic, it may be that the whole range is volcanic in nature or origin—an off-shore volcanic range. The line of this chain of elevations, moreover, if continued southwestward, passes just outside of Newfoundland and the Atlantic border of the United States.

7. *Journal of the American Electrical Society, including Original and selected papers on Telegraphy and Electrical Science.* Vol. I, No. 1. 100 pp. 8vo, with several wood-cuts. Chicago: 1875. Published for the American Electrical Society.—A new, handsomely printed journal, devoted to electrical discoveries, and the various practical applications of electricity. The first paper is on the transmission of musical notes telegraphically, by Elisha Gray. The author closes with the statement that, "by this method, not only may different messages be sent simultaneously, but a tune with all its parts can be distinctly audible at the receiving end."

APPENDIX.

ART. XVIII.—*Principal Characters of the Dinocerata;* by O. C. MARSH. With five plates.

THE huge Eocene mammals, discovered by the writer in 1870, and subsequently placed in the new order *Dinocerata*, prove to be a well marked group of much interest. The Yale College Museum now contains remains of more than a hundred individuals, some of them in such excellent preservation that few points in the osseous structure of these animals need longer remain in doubt. It is proposed, therefore, to give, in the present communication, the more important characters of the members of this order, reserving the detailed description for a separate memoir. Although several distinct genera of *Dinocerata* are now known, as shown below, the typical characteristics of the group are best seen in *Dinoceras*, and hence I describe first that genus, which is especially illustrated in the accompanying plates.

DINOCERAS Marsh, 1872.*

The skull in *Dinoceras* is long and narrow, the facial portion being greatly produced. The basal line, extending from the lower margin of the foramen magnum along the palate to the end of the premaxillaries, is nearly straight. The top of the skull supports three separate transverse pairs of osseous elevations, or horn-cores, which form its most conspicuous feature, and suggested the name of the genus. The smallest of these protuberances are situated near the extremity of the nasals; a second much larger pair rise from the maxillaries in front of the orbits; while the largest are on the parietals, and supported by an enormous crest, which extends from near the orbits entirely around the lateral and posterior margins of the true cranium. (Plate II.) The posterior crest, which curves upward and backward beyond the occipital condyles, is mainly composed of the supra-occipital. The floor of the deep depression in front of this crest is formed by the parietals. These bones also send up the lateral crests. The top of the skull between the orbits is formed of the frontal bones, which are remarkably short. Their superior sutures with the parietals pass just in front of the lateral crest, and then converge posteriorly. There is no postorbital process, but in some species of

* This Journal, iv, 343, v, 117, 293 and 310.

the genus there is a prominence on the frontal, directly over the orbit. The nasals are greatly elongated, being nearly half the length of the entire skull. They unite with the frontals by oblique sutures, directed backward and inward, and nearly parallel with the superior fronto-parietal sutures. (Plate II, figure 3.) The osseous protuberances on the extremities of the nasals are of moderate size in *Dinoceras*, but, like the maxillary horn-cores, vary much with age. Both may possibly have been covered with thick skin, and not with true horns.

The orbit is large, and confluent with the temporal fossa. The latter is of great extent posteriorly, but the zygomatic arches are only moderately expanded. The squamosal forms the lower portion of the temporal fossa, and sends down a massive post-glenoid process, which bounds in front the external auditory meatus. The latter has for its posterior border the post-tympanic process of the squamosal, which unites directly with the paroccipital, thus excluding the mastoid from the external surface of the skull, as in *Rhinoceros*. The tympanic portion of the periotic, also, does not reach this surface. There are small air-cells in the walls of the temporal fossa, both in the squamosal and parietals. The squamosal sends forward a strong zygomatic process, which resembles that in *Tapirus*. The malar completes the anterior portion of the arch, extending to the front of the orbit. (Plate II, figure 1.) The lachrymal is large, and forms the anterior border of the orbit. It is perforated by a large foramen. The maxillaries are massive, and quite remarkable in supporting a pair of stout, conical horn-cores, which vary in form and size in different species. These cones are solid except at the base, which is usually perforated for the fang of the canine tusk. The premaxillaries are elongated, and without teeth. They unite posteriorly with the maxillaries just in front of the canine, and then divide, sending forward two branches, which partially enclose above and below the lateral portion of the narial aperture. (Plate II, figure 1.) The lower portion is slender, and resembles the premaxillary of some Ruminants. The premaxillaries are not united at their extremities. The latter are rough, and probably supported a pad.

The palate is very narrow and deeply excavated, especially in front. The anterior palatine foramina are in the premaxillaries, and vary much in different species. In *D. mirabile* they are elongated fissures, enclosed between the lateral and palatine branches of the premaxillaries, as in *Equus*. In *D. laticeps* they are of small size, and oval in outline. The posterior palatine foramina are in the maxillaries near the anterior border, as in *Hippopotamus*. The posterior nares extend forward between the last upper molars. The occipital condyles are large, and bounded externally in front and below by a deep groove. They

project downward and backward, showing that the head was declined when in its natural position. The exoccipitals are perforated by a condylar foramen of moderate size, which is separated from the larger foramen lacerum posterius by a slender partition of bone. Between the post-glenoid process and the basi-sphenoid, there is an irregular cavity filled in part below by the periotic. There is a distinct alisphenoid canal, and the foramen ovale is near its posterior orifice. In front of its anterior opening, is a small foramen lacerum anterius, and further forward, the optic foramen. The infraorbital foramen is large, and partially concealed behind the maxillary ridge which supports the malar.

The brain cavity in *Dinoceras* is perhaps the most remarkable feature in this remarkable genus. It proves conclusively that the brain was proportionately smaller than in any other known mammal, recent or fossil, and even less than in some reptiles. It was, in fact, the most reptilian brain in any known mammal. In *D. mirabile*, the entire brain was actually so diminutive that it could apparently have been drawn through the neural canal of all the presacral vertebræ, certainly through the cervicals and lumbars. The size of the entire brain as compared with that of the cranium is well shown in the accompanying cut, figure 1.

1.

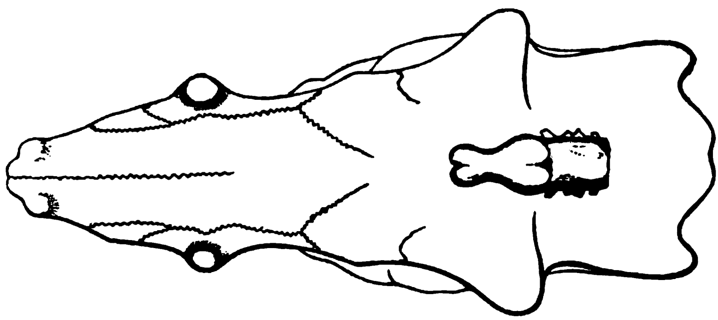


Figure 1. Outline of Skull and Brain Cavity of *Dinoceras mirabile*. Top view; one-eighth natural size.

The most striking feature in the brain cavity itself is the relatively small size of the cerebral fossa, this being but little larger than the cerebellar portion. This is shown in Plate IV, the figures of which are drawn from a cast of the brain cavity of *D. mirabile*, the type of the genus. The cerebral hemispheres did not extend at all over either the cerebellum or the olfactory lobes. The latter were large, and continued well forward. The hemispheres were apparently convoluted, and the Sylvian fissure distinctly marked. There was a rudimentary

tentorial ridge. The cerebellar fossa is but little larger transversely than the medullar canal, and has lateral cavities which may have been occupied by flocculi. The pituitary fossa is nearly round, and of moderate depth. There are no clinoid processes. The brain as a whole resembled that in some Marsupials more than in any other known mammals. Its small size, as the writer has elsewhere shown, is a character apparently pertaining to all Eocene mammals;* the brain-growth during the rest of the Tertiary period having been gradual, and mainly in the cerebrum.

The teeth in *Dinoceras* are represented by the following formula:

$$\text{Incisors } \frac{0}{3}; \text{ canines } \frac{1}{1}; \text{ premolars } \frac{3}{3}; \text{ molars } \frac{3}{3}; \times 2 = 34.$$

The superior canines are long, decurved, trenchant tusks. They are covered with enamel, and their fangs extend upward into the base of the maxillary horn-cores. There is some evidence that these tusks were small in the females. Behind the canine, there is a moderate diastema. The molar teeth are very small. The crowns of the superior molars are formed of two transverse crests, separated externally, and meeting at their inner extremities. The series is well shown in Plate III, which represents the upper premolars and molars of *D. mirabile*. The first true molar is smaller in this specimen than the two preceding premolars. The last upper molar is much the largest of the series.

The lower jaw in *Dinoceras* is as remarkable as the skull. Its most peculiar features are the posterior direction of the condyles, hitherto unknown in Ungulates, and a massive decurved process on each ramus, extending downward and outward below the diastema. (Plate V.) The position of the condyles was evidently necessitated by the long upper tusks, as, with the ordinary ungulate articulation, the mouth could not have been fully opened. The low position of the condyle, but little above the line of the teeth, is also a noteworthy character. The long pendant processes were apparently to protect the tusks, which would otherwise be very liable to be broken. Indications of similar processes are seen in *Smilodon*, and some other Carnivores with long upper canines. With the exception of these processes, the lower jaw of *Dinoceras* is small and slender. The symphysis is completely ossified. The six incisors were contiguous, and all directed well forward. Just behind these, and not separated from them, was the small canine, which had a similar direction. The crowns of the lower molars have transverse crests, and the last of the series is the largest. (Plate V, figure 3.)

The vertebræ in *Dinoceras*, in their main characters, resemble

* This Journal, viii, p. 66, July, 1874.

those of Proboscidians. The atlas and axis are very similar to those of the elephant, but the rest of the cervicals are proportionally longer. The dorsal and lumbar vertebræ have the articular faces nearly flat, and the lumbars have an inferior ridge on the median line. There are four sacral vertebræ, the last being quite small. The anterior caudals have long, depressed, transverse processes. The ribs resemble those in *Mastodon*. The segments of the sternum were well ossified, and most of them were flattened vertically.

The scapula, in its general form, is similar to that of the elephant, but there is much less constriction above the glenoid fossa. The latter is elongate, deeply concave longitudinally, and nearly flat transversely. The spine extends downward nearly to the glenoid border. The coracoid portion is a rugose protuberance, separate from the margin of the articular fossa. The humerus is short and massive, and in its main features resembles that of the elephant. One of the most marked differences is seen in the great tuberosity, which does not rise above the head, and is but little compressed. The condylar ridge, moreover, of the distal end is tubercular, and not continued upward on the shaft. The lower extremity of the humerus is much like that of the rhinoceros, and the proportions of the two bones are essentially the same. The radius and ulna are nearly of the same size. The head of the radius rests on the middle of the ulnar articulation, and hence the shaft of this bone does not cross that of the ulna so obliquely as in the elephant. The ulna has a small face for articulation with the lunar, as in the elephant.

There are five well developed toes in the manus, which is well shown in Plate VI, figure 2. The carpal bones are eight in number, and form interlocking series, as in Perissodactyls. The scaphoid resembles that bone in the elephant, but is shorter and stouter. Its proximal end is rounded, forming about one-fourth of a sphere. On its distal end, the articular faces are confluent. It supports the trapezium and trapezoid. The pyramidal sends down an outer angle to articulate with the fifth metacarpal, as in *Elephas*. The trapezoid is the smallest bone in the carpus. The magnum is supported by the lunar, and not at all by the scaphoid. The unciform is the largest carpal bone. It has the usual metacarpal faces well marked, and separated by ridges. The metacarpals are of moderate length, and the third is about equally supported by the magnum and unciform. The articulations for the phalanges are nearly flat, indicating but little motion. The phalanges are very short, and the distal ones rugose.

The pelvis is much expanded, as in Proboscidians. The ilium is suboval in outline. The pubis is slender and short,

and the ischium has less posterior extension than in the elephant. The thyroid foramen is an elongate oval. The femur is proportionally about one-third shorter than that of the elephant. The head of this bone has no pit for the round ligament, and the great trochanter is flattened and recurved. There is no indication of a third trochanter. The distal end of the femur is more flattened transversely than in the elephant, and the condyles are more nearly of the same size. The corresponding articular faces of the tibia are consequently about equal, and also contiguous, with no prominent elevation between them. When the limb was at rest, the femur and tibia were nearly in the same line, as in the elephant and man. The patella is elongate, and oval in outline. The fibula is slender, and entire, with articular faces well marked at each extremity. The astragalus has no distinct superior groove. Its anterior portion has articular faces for both the navicular and cuboid, thus differing from Proboscidians, and agreeing with Perissodactyls. The calcaneum is very short, its longitudinal and transverse diameters being about equal. It does not articulate with the navicular, as in *Elephas*, and has only a small face for the cuboid. There are four well developed digits in the pes, and a rudimentary or small hallux. The metatarsals are much shorter than the metacarpals. The phalanges and sesamoid bones are smaller, but otherwise similar to those of the manus. The hind foot is shown in figure 1 of Plate VI. None of the bones of the skeleton are hollow.

The known species of *Dinoceras* nearly equalled the elephant in size, but the limbs were shorter. The head could reach the ground, and there is no evidence of a proboscis. All the remains of the genus yet discovered are from the Eocene of Wyoming.

Yale College, New Haven, Jan. 18th, 1876.

(To be continued.)

EXPLANATION OF PLATES.

Plate II.—*Dinoceras mirabile* Marsh. Figure 1, side view of skull; figure 2, front view; figure 3, top view. One-eighth natural size.

Plate III.—*Dinoceras mirabile*. Superior premolar and molar teeth; bottom view. Three-fourths natural size.

Plate IV.—*Dinoceras mirabile*. Cast of brain cavity. Figure 1, side view; figure 2, top view; figure 3, bottom view. One-half natural size.

Plate V.—*Dinoceras laticeps* Marsh. Lower jaw. Figure 1, front view; figure 2, side view; figure 3, top view. One-fifth natural size.

Plate VI.—*Dinoceras*. Figure 1, hind foot; figure 2, fore foot. One-third natural size.

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[THIRD SERIES.]

ART. XIX.—*On the Veiled Solar Spots*;* by L. TROUVELOT.

[Read before the American Academy by William A. Rogers, Oct. 12, 1875.]

IT is now pretty well established that the visible surface of the sun is a gaseous envelope called "the chromosphere;" mainly composed of incandescent hydrogen gas, with which are occasionally associated some metallic vapors, usually occupying the lower strata. To all appearances, the granulations called "rice grains," the faculæ and the protuberances, are phenomena belonging to the chromosphere; in fact they are the chromosphere itself seen under the particular forms and aspects peculiar to it. Ordinarily this envelope has a thickness of 10″ or 15″. This thickness, however, is by no means constant, varying from day to day within certain narrow limits.

At no time since I have observed the sun have I seen the chromosphere so thin and shallow as during the present year, and especially between June 10 and August 18. I had before quite often observed local depressions and upheavals of the chromosphere, sometimes extending over large surfaces, but I had never before observed such a *general* subsidence.

So thin was the chromosphere during this period that it was sometimes very difficult to obtain its spectrum by placing the slit of the spectroscope tangent to the limb of the sun. This was especially the case on the afternoon of August 9.

This unusual thinness of the chromosphere could be easily recognized without the assistance of the spectroscope. Indeed, the phenomenon was even more interesting seen through the telescope, as, with it, the structure of the photosphere, lying as

* From the Proceedings of the American Academy.

it does under the envelope of the chromosphere, could be better seen through the thin veil formed by the greatly attenuated chromospheric gases.

That the gases forming the chromosphere are sometimes thin enough to become transparent is a phenomenon which I have observed hundreds of times; as is abundantly proved by the numerous drawings of protuberances which I have made at the Harvard College Observatory, in which the limb of the sun is seen through the base of the protuberances in front of it. In plate X, figure 3, there occurs a very striking instance, where two small prominences are seen through a large protuberance nearer the observer.

During this period of general subsidence, the granulations appeared to be smaller and farther apart than usual, and consequently the light-gray colored background upon which they are seen projected was more distinct, as it occupied more space than formerly. During this period, the light-giving element would appear to have been less than usual.

I am not aware that the phenomena of which I shall speak in this communication have been before observed; but I cannot speak positively on this point, owing perhaps to the somewhat confused nomenclature of solar physics.

Ever since I have observed the sun with instruments of a large aperture, I have noticed that the light-gray colored background seen between the granulations is by no means uniform, as it is generally stated to be. On the contrary it is greatly and strikingly diversified. Aside from the very small black dots called "pores," patches of a darker gray are irregularly distributed all over the surface of the sun. But partly owing to the effect of perspective, and partly on account of the thicker strata of the chromospheric gases through which they are necessarily seen near the limb, they disappear gradually as they approach the border.

These dark spots have been so remarkable during the present year, and so conspicuous during the period of the greatest subsidence of the chromosphere, that I have availed myself of every favorable opportunity to study them. So strongly were they marked that when one had passed the field of view, it could be easily found again among many others, even after the lapse of several hours. Of the most striking and complicated, I have made sketches.

In order to be able to count how many of these gray spots could be seen in different heliographic latitudes, and also to estimate their area with respect to the whole surface of the sun, Mr. W. A. Rogers, assistant at the Harvard College Observatory, kindly ruled for me on glass a reticule of small squares. Though the problem is apparently a simple

one, it nevertheless presented many difficulties; partly owing to the minuteness and delicacy of these objects, partly on account of the unsteadiness of the atmosphere, and partly to the many defects caused by the great amount of heat concentrated at the focus of the objective. However, the observations show clearly that though the number of gray spots varies but very little in different latitudes, in general the spots become larger and more complicated as they approach the equatorial zones.

The most marked characteristic of the gray spots is their vagueness of outline. They are never sharply defined like ordinary spots, but they appear blurred and diffused like an object seen through a mist. As I shall endeavor to show presently, these objects are really seen through chromospheric gases which are spread as a veil over them, causing this vagueness of outline. For this reason, I propose for them the name of *Veiled Solar Spots.*

The veiled solar spots, especially in the lower latitudes, have a remarkable tendency to assemble into small groups after the manner of ordinary spots. Sometimes three or four are seen in contact, while there are comparatively large intervals where none are to be seen. I have in several instances seen the actual formation into groups of distinct veiled spots.

The granulations of the chromosphere are seen projected upon the veiled spots, just as anywhere else, but they are not there so regularly distributed; some being closely crowded together, while others are widely scattered. Small faculæ are often formed in this manner by the aggregation of several granules into one mass. Once in a while the granulations appear as if they were under the power of a propelling force by which they arrange themselves in files, and sometimes in capricious figures which are very remarkable.

In many cases I have observed that the granulations projected upon the veiled spots have an extraordinary mobility, to be seen nowhere else, except perhaps in the immediate vicinity of ordinary spots in full activity. Often their form and position are totally changed within a few minutes, and sometimes even within a few seconds. This was especially the case June 21. At $8^h\ 30^m$ on that day, I was observing a group of veiled spots not far from the center of the sun, when my attention was drawn to the extraordinary mobility of the granulations covering this group. In an instant they changed their form and position, some crowding together as though briskly attracting each other, while others would fly apart as if repelled by an invisible force. Under this tumultuous conflict of forces, new veiled spots would appear and disappear in an instant, faculæ would form and vanish; in fact, all was in motion and confusion on that particular part of the sun. It was evident that immense forces were in conflict under the chromosphere.

At 2^h 0^m P. M., on the same day, several small black spots had opened through the chromosphere upon the group of veiled spots observed in the morning. At 8^h 0^m on the following morning, the group of small black spots was considerably increased, having quite a large spot on the preceding side, followed by twelve or fifteen smaller ones. On June 24, this group had attained to its maximum size. It was then very large and complicated. In fact, it was the largest group of sun spots observed thus far during the present year.

On August 8, I noticed a group of veiled spots a little south of the sun's center. The following morning at 7^h 0^m, there was at the same place a small group of half a dozen black spots disposed in a crescent shape. At 2^h 0^m P. M., the black spots had vanished, but the veiled spots still remained, having retained the characteristic crescent form of the black spots and many other details observed in the morning; and, as a proof that the chromosphere covered this spot, *the granulations could be plainly seen upon the whole, indicating clearly that this spot was seen through the veil of the chromospheric gases.*

On August 24, the same phenomenon took place. Just following the principal spot of the only group then to be seen on the surface of the sun, there was a fine group of veiled spots. The following day some black spots had made their appearance upon them. On August 27, the black spots had vanished, but in their place the veiled spots seen at first still remained, and they continued to be seen there for several days.

To all appearances, the black spots which I had seen disappear under the chromospheric gases, and which continued as veiled spots, were exactly alike and undistinguishable from the many other veiled spots scattered all over the sun; and, had I not seen the opening of the photosphere, with the black spots, I could not have had any idea of the true nature of the veiled spots.

So far, I have only spoken of veiled spots observed in the zones where the ordinary sun spots usually make their appearance; but, as I have said, the veiled spots are scattered all over the surface of the sun.

During this period, I had many occasions to observe very remarkable and characteristic veiled spots in very high heliographic latitudes north and south. On July 15, within a few degrees of the north pole of the sun, I observed a remarkable veiled spot, unusually large and dark. Upon it were several bright slender faculæ projected in crest shape to very high altitudes. These faculæ appeared to be precisely like those observed in lower latitudes near ordinary sun spots. Upon this veiled spot could unmistakably be seen a small black spot, not a pore; a real opening of both chromosphere and photosphere.

On August 9, I observed another remarkable veiled spot within about 10° from the north pole, and upon it could be seen three small black spots.

On August 13, at $11^h\ 0^m$, I observed a very dark veiled spot within 6° or 8° from the north pole. It had upon it a group of small faculæ, so characteristic of the spots of lower latitudes. At $4^h\ 30^m$ in the afternoon, this veiled spot was still darker, and upon it, near a facula, a pretty large black spot was visible.

On August 24, I observed a remarkable veiled spot at about 75° south latitude.

On September 6, another large group of veiled spots was seen within 10° or 15° of the north pole. At $10^h\ 20^m$, some faculæ had formed upon it, and two black spots were distinctly visible. At $5^h\ 0^m$ in the afternoon, this group was still visible.

On September 8, within a few degrees of the north pole, I observed a fine group of two veiled spots, unusually dark and large, and near one of these spots there was a pretty large and bright facula. Ten minutes later the dark veiled spots had vanished, leaving in their place some bright faculæ. One minute later the veiled spots began to reappear, but under another form, to disappear again the next moment.

A little southwest from this last group, but in the same field of view, was another group of veiled spots apparently in full activity. Upon it three or four black spots were visible for some seconds. Upon these veiled spots the granulation had an extraordinary mobility; so much so, that I expected at every moment to see a large spot make its appearance, but in less than a minute the veiled spots and the black spots had both vanished, and in their place were formed in an instant, some very bright faculæ.

To all appearances, the veiled spots seen in high latitudes differ but very little from the ordinary sun spots of the lower latitudes, except in regard to magnitude and activity. The difference seems particularly to be that, in the first, the umbra, instead of being freed from the gases and vapors, is partly or wholly choked with them; while, besides, the chromosphere covers it. The forces which open the photosphere in high latitudes, it would seem, have not sufficient energy to repel or dissolve the chromospheric gases; or, if they have, it is in a very feeble degree, but, even then, the phenomenon is generally of short duration.

Though I had no means of making accurate measurements of the positions of the spots seen in high latitudes, the error of my estimation cannot be very great. In any case a few degrees would certainly cover it, and it remains a fact that I have observed spots at least within 10° of the north pole of the sun. The importance of this observation will appear when it is stated

that very few spots have been observed outside of the zones lying 40° on either side of the equator. I know of but two instances on record in which spots have been observed beyond this limit. La Hire observed a spot 70° from the equator, and more recently, in the month of June, 1846, Dr. C. H. F. Peters observed at Naples a spot 50° from the equator.

It is further to be remarked that according to the conclusions of the English observers, the solar spots attain higher latitudes during the years of the maximum number of spots, and recede more and more towards the equator as the minimun is approaching; and it is to be noted that the present year is precisely, or at least very nearly, a minimum year. It is doubtless owing to the unusual thinness of the chromosphere during this period that spots have been observed in so high latitudes this year. It is true that the spots were small, but, nevertheless, they were genuine spots, with all the characteristics of larger spots.

It is difficult for one who has seen the phenomena which I have described, to come to any other conclusion than this: that the veiled spots are breaks or true openings in the photosphere, seen through the imperfectly transparent gases composing the chromosphere, openings themselves partly or wholly filled by the vapors ejected by the forces from the interior of the photosphere. If this hypothesis should prove to be the expression of a fact, then we should expect to find that the photosphere is perforated by thousands of crevasses either partly or entirely filled with the vapors and gases from the interior, which cannot be ejected outside for want of sufficient energy, save for a comparatively very small number situated in the equatorial zones, where this energy appears maximum, and is able to repel and dissolve the gases from the interior.

Before the observations of this year, I had arrived at precisely the same conclusions in regard to the opening of the photosphere in all latitudes, and to the existence of invisible spots concealed by the chromosphere. These conclusions were derived from my observations with the spectroscope, made at Harvard College observatory during a period of thirty-five months. A discussion of these observations is reserved for a future communication.

Though one can hardly form a settled opinion with regard to the cause of the general depression of the chromosphere, on account of the imperfect data, it seems natural, however, to suppose that the phenomenon is connected in some way with the minimum period of sun spots. Judging by the great number of veiled spots observed, and by the myriads of pores seen between the granulations, it would seem that both the chromosphere and photosphere have been much thinner than usual during the present year.

If there are breaks in the photosphere at many points of the surface of the sun, it becomes easy to account for the unusual thinness of the chromosphere this year, because as observed by myself and others, at certain phases of the spots, the chromospheric gases, rushing with impetuosity into the umbra, go down under the photosphere like gigantic waterfalls, diminishing consequently the thickness of the chromosphere. That this takes place I shall give ample proof in another communication.

It seems evident that the chromosphere near a spot is kept from falling into the opening by a force from the interior. As soon as this force decreases in energy, immediately the chromosphere tends to cover it, and even to precipitate itself through the opening when this force becomes extinct. The observations show this plainly.

When a spot is decreasing, it is quite common to observe that the umbra and penumbra appear as if they were seen through a heavy fall of snow, their surfaces being covered by numerous bright flocculent granulations surrounded by a kind of bluish fog. In a few instances of very rare definition, I have been surprised to see faint traces of this flocculent appearance upon almost all the spots; indeed it would seem that the spots are rarely free from some faint traces of the chromospheric gases. Probably the bright flocculent objects observed upon the umbra and penumbra of spots, are the granulations of the chromosphere dissolved to a greater or less degree by the forces emanating from the spots.

Perhaps it may not be idle to remark that, during the period mentioned, I have almost every day observed small groups of faculæ in the polar regions, especially near the north pole of the sun; while, for the most part, they have been entirely absent from the equatorial regions, where they are commonly found.

To conclude, my observations show:

1. That during this year, and especially during the interval from June 10 to August 18, and to a less degree to September 14, the chromosphere has been notably thinner than usual upon the entire surface of the sun.

2. That the granulations have been smaller and less numerous.

3. That the light-gray colored background seen between the granules has been more conspicuous and has occupied more space than usual.

4. That there are spots, which I have named "veiled spots," which are seen through the chromospherewhich is spread over them like a veil.

5. That these veiled spots are true openings of the photosphere, like those of the ordinary spots.

6. That during this period these spots have been larger, darker, and more numerous than I have before seen them.

7. That the veiled spots are scattered throughout all latitudes, though more complicated in the regions where the ordinary spots make their appearance.

8. That I have observed spots at least within 10° of the north pole of the sun.

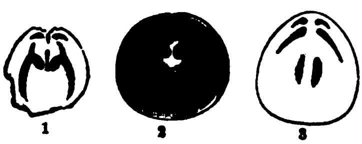
9. That the flocculent objects sometimes seen projected upon the umbra and penumbra of spots are the remaining portion of the granulations composing the chromosphere, more or less dissolved by the forces emanating from the interior of the photosphere.

Cambridge, October 1, 1875.

ART. XX.—*On the structure of Obolella chromatica;* by E. BILLINGS, F.G.S.

THE genus *Obolella* was founded in 1861,* on the following three species of Brachiopoda:

1. *O. chromatica*, discovered by J. Richardson in 1861, at a place called "L'Anse au Loup," on the north shore of the Straits of Belle Isle, in Labrador.
2. *O. crassa* Hall, from Troy, in the State of New York.
3. *O. polita* Hall, from Wisconsin.



Figs. 1, 2.—Ventral valves. The beak is not seen in either of the specimens.
Fig. 3.—Diagram showing the position of the scars in the dorsal valves. All these figures are enlarged about 2½ diameters.

The specimens exhibited the internal characters very imperfectly, yet enough was seen to convince me that the genus was a new one. During the fourteen years that have elapsed, I have received a number of letters, from both American and European authors, inquiring for more complete details of the structure of *O. chromatica*, which has always been considered to be the type. This information I was unable to give, for want of the facts. We are now in possession of specimens showing the interiors of both valves, almost completely. The following are the characters as nearly as they can be made out:

In the ventral valve there is a groove in the hinge line, for the passage of the pedicel. On each side of the groove there is a small, somewhat deeply excavated cardinal scar. In the cavity of the valve there are two elongated scars, which extend

* Geology of Canada, Palæozoic Fossils, vol. i, p. 7, 1861.

from near the cardinal scars forward about two-thirds of the length of the shell. These diverge from each other, more or less, in their extension forward, and are usually curved but sometimes nearly straight. They may be called laterals. They are, in general, separated from each other about one-third of the width of the shell. A little above the mid-length, and between the two laterals, there is a pair of small scars arranged transversely, with their inner extremities directed somewhat forward. The space above these two scars, between the upper portion of the laterals, is generally tumid from the thickening of the shell. In one of the specimens there is a small pit in the center of this space.

The dorsal valve has a small area, or nearly flat hinge facet. The minute beak is slightly incurved over the edge of the area. Beneath the beak there is a small sub-angular ridge, on each side of which there is a cardinal ? scar. The elongated scars, which seem to correspond to the laterals of the ventral valve, are here altogether in the upper half of the shell. They diverge widely in their extension forward. They are in general very slightly impressed, and would, most probably, escape the observation of any one who did not expect to find scars where they are situated. In the cavity of the valve there is a low rounded median ridge, which extends from a point near the hinge line forward a little below the mid-length of the valve. About the middle of the shell there are two small scars. These are usually striated longitudinally. The median ridge passes between them. The area is coarsely striated.

The above are the principal characters of this species, and they are subject to some variations, one of which is particularly worthy of notice. The two small cardinal scars of the dorsal valve are sometimes elongated laterally. This is carried to such an extent in another species (*O. gemma*) that they not only extend the whole length of the hinge-line, but are curved forward at their outer extremities and continued down into the cavity of the valve. In such cases they present an appearance similar to that of the groove beneath the hinge-line of the genus *Obolellina*. In other species of this genus the lateral scars of the dorsal valve are sometimes connected together by their upper extremities. But this is not a constant character. In different individuals, of the same species, these scars are either connected or not. The laterals are also sometimes connected with the cardinals.

The following are the original figures published in the Paleozoic Fossils, p. 7, (1861):

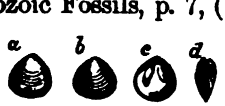


Fig. 4

Fig. 4, *a*, Ventral valve; *b*, dorsal; *c*, interior of ventral valve, showing the muscular impression; *d*, outline on a side view, restored from detached valves. Natural size.

In the description it is said: "Muscular impressions in the ventral valve, four; one pair in front of the beak, near the middle or in the upper half of the shell." The pair here alluded to are the laterals. Their upper and lower extremities are sometimes not visible, and what remains occupies the middle portion of the length of the shell. The expression "or in the upper half," I can thus explain: I had the dorsal valve of *O. crassa*, from Troy, which I then supposed to be a ventral valve. In this the laterals are in the "upper half." The transverse scars were not then observed and hence four scars instead of six. It must be borne in mind that fourteen years ago nothing was known of the internal characters of these shells. The materials were imperfect and consequently so was the description. It is now certain that the genus is a good one and that all of the three species on which it was founded belonged to it.

The described species which I consider to be truly within the genus are: *O. chromatica*, *O. polita*, *O. crassa*, *O. nana*, and *O. gemma*. They all, so far as is yet known, are confined to the *Potsdam Epoch*. A number of other species have been referred to the genus, but they are all more or less doubtful.

The specimens which have furnished the above additional details of the structure of *O. chromatica* were collected at L'Anse au Loup, the only place where the species has been found, in 1863, by T. C. Weston of our Survey, and by him very skilfully worked out of the matrix.

Art. XXI.—*On the Damming of Streams by drift ice during the melting of the great Glacier;* by J. D. Dana.

When treating of the overflows of the flooded Connecticut, in the Supplementary December Number of this Journal, (p. 497,) I suggested, in view of the fact that the terraces in the Farmington Valley about Tarifville and Simsbury are at least 50 feet higher than those a mile eastward in the parallel Connecticut valley—that the gorge through the Divide Range, by which the Farmington river there passes into the Connecticut valley, had been closed by drift and so remained until the flood had reached its height.

I allude to this subject again to add that the events connected with the opening, in the Spring, of many of our modern ice-covered streams afford abundant reason for believing that, during the breaking up of the long Glacial winter, when the melting was going forward, the gaps, gorges or narrows, along the river courses, would have been liable to obstruction by floating ice.

(*a*) Such obstructions would have been of all grades, from that which could simply impede the free flow of the waters, to the nearly perfect dam.

(*b*) The obstructions in particular cases might have existed for a very long era, instead of for a few weeks such as happens after a modern winter.

(*c*) Again, the slackened or suspended flow of the water, caused by such ice-obstructions, would have favored the deposition and accumulation about them of drift, and some may have thus been converted into complete dams. This process might occasionally have wholly filled with earthy material a gorge or narrow valley, so as to block up and divert the course of the stream.—The well-known case of Niagara River may be an example of this.

In view of these possible results, or rather these probable conditions of many river-valleys in the era of the Glacial flood, we are required to consider whether the height of the upper terraces *above the narrows* on the several rivers,—the Thames below Norwich, the Connecticut below Middletown, the Housatonic below Derby, Westfield River below Westfield, and Farmington River east of Tarifville—was not partly owing, in each case, to the existence of ice-obstructions at the narrows.

It seems to be very probable that this was so. The height of modern spring floods in the Connecticut at Middletown and Hartford is now often due in part to this very cause.

It appears to be certain, that if such obstructions existed in the Thames, Connecticut and Housatonic valleys, they were only partial obstructions; for, in the case of each, the terrace of the valley below the narrows *declines quite gradually in height* from the level above the narrows, instead of abruptly. Had the waters been held back, up to the height of the high upper terrace, by a close dam, they would have fallen over the dam with a plunge to a lower level; and this abrupt fall would have been registered by means of an abrupt fall in the level of the terrace. Instead of this, the terrace on passing the narrows southward falls off at a rate not exceeding 10 feet a mile, varying in rate only with the varying width of the valley: a fact that seems to testify to the vastness of the flood as its cause, and not mainly to obstructions. Moreover, the material of the terraces below the narrows is like that above: the same in the prevalence of sands below and coarse gravel at top,—though having the latter of greater coarseness because of the more rapid flow of the stream along a narrower valley.

Further evidence with reference to the existence of such ice-barriers is to be looked for in a distribution of gravel and large bowlders across the valley just above the gorge or narrows, where the ice-masses had been brought to a stop and piled together;

for much of the floating ice would have been loaded with bowlders. I have as yet observed no satisfactory evidence of this kind, but think the question needs more investigation. Even if this evidence fails, we can hardly assert that no aid was afforded by ice in producing the great height of the flood-waters above the narrows, or doubt that ice-barriers made of drift ice had much to do with the height and extent of the upper terraces in portions of many other valleys.

There are two questions which should have here a word.

1. *May not the obstructions or dams have been made by the Glacier itself?* On this point we observe that the extent of the terrace formations along the valleys,—sometimes a score of miles in width even in New England—show that water swept in immense streams over the surface; and thus they seem to prove that the glacier was already out of the lower part of the valleys, and hence too far away to have obstructed the flow except through the pieces set afloat by its dissolution.

2. *Were not the dams due to rocky barriers at the narrows, or to the non-excavation of the valley from the narrows southward?* The features of the region about the narrows on each of the rivers mentioned, and of the valleys below, suggest decidedly that the valleys had nearly the same depth and extent then as now. The gradual decline in the height of the terrace on going from the narrows southward to the Sound shows that all was one valley, the part above the narrows and its continuation below. The terraces below the narrows, moreover, are built up in general from the *present* bottom of the valley, or from a lower depth, and this points to a depth for the valley as great as now or greater. It cannot be urged that the lower portions of the terraces were made after the upper. Wherever the hills on one side, at the narrows, retreat so as to give a chance for high terrace deposits, there these deposits are usually found, and sometimes the beds rise abruptly from the water's edge to the level of the highest terrace; and on the Connecticut, in a place of this kind above Middle Haddam, the bottom layers are of clay—like the lower layers in much of the stratified drift on the river.

In fact, the conditions of the terrace deposits of the valley, as well as the features of the valley itself, are explicable only on the view that the part of each valley below the narrows, like the rest of it, the narrows included, had been made before the Champlain period opened. The Glacial period was the era of valley excavation rather than the Champlain period.

ART. XXII.—*Sliding Friction on an Inclined Plane;* by A. S. KIMBALL, Professor of Physics in the Worcester (Mass.) Institute of Industrial Science.

THE following investigation was undertaken with a desire to demonstrate, if possible, by a laboratory experiment, that the law which affirms that the coefficient of sliding friction is constant for all velocities is not strictly true.

Our results seem to establish the point, at least in the case of bodies sliding down an inclined plane. I am aware that the truth of this law has been questioned; indeed the opinion of very many practical mechanics is directly opposed to it. Long ago Prof. Playfair remarked, as the result of some observations made at the slide of Alpnach, that it would appear that friction is neither proportioned to the pressure nor independent of the velocity. Later observations made at the launching of the Raritan and the Princeton (Jour. Frank. Inst., 3d, VII, 108) showed that the coefficient of friction just before the vessel left the ways was much less than during the first five seconds of its motion. More recent still are the experiments of M. Bochet (Comptes Rendus, April 26, 1858,) upon the friction of railway carriages and brakes, which point to the same conclusion; indeed the author goes so far as to give the form of the function which expresses the variation of the coefficient of friction with the velocity, and gives approximate values to its constants for the case of railway trains. His formula is copied by Weisbach with a caution.

Opposed to these views are the careful experiments of Coulomb and Morin, upon which the statements of our text-books are founded.

The apparatus used in our experiments was simple, but it seems capable of giving very sharp and reliable results. A smooth pine plank 10′×12″×2″ was firmly placed at a measured angle with the horizon and supported throughout by stout beams. Upon this plank was a weight box with pine runners, having a bearing surface of 24 square inches. The cover of the box was about six feet in length, and upon it were placed slips of smoked glass. Firmly fixed above the glass, to an independent support, was a verified tuning fork of 435 complete vibrations per second, carrying a style which lightly touched the glass surface beneath it. The weight box was supported in position at the upper end of the inclined plane by a cord fastened to a screw which served to give the box a very slow upward motion. At the proper time the screw was turned, the fork vibrated, the cord cut or burned off, and the box allowed to slide to the bottom of the plane. The style of the fork at the same time

would trace upon the smoked glass a waved line, which would be a perfect autographic register of the experiment. The time of sliding, the velocity at any point, the distance passed over in any unit of time, could all be measured or counted directly from the smoked glass.

The graphical method of working up the experiment was employed, as follows: The bottom of a sheet of section paper was made a "time line" ($\frac{1}{123}$ of a sec.= a unit). At various points on this line the corresponding velocities were erected as ordinates. The equation of a line connecting the upper extremities of these ordinates would express the law of the motion studied.

It is evident that this line would have been straight if the acceleration of the slide had been uniform, like that of a body falling in vacuo. If, however, a variable resistance be opposed to the motion of the slide, the acceleration will no longer be uniform, and the line will become curved, concave toward the axis of abscissas, if the resistance is increasing, convex if the resistance diminishes. The acceleration of such a motion at any time will be proportional to the tangent of the angle which the direction of the curve at that point makes with the time line. It is also evident that such acceleration may at once be measured from the paper, since it is the difference between the velocities for two successive units of time. The curve constructed as above, from every experiment made, was decidedly convex toward the time line, showing a constantly decreasing resistance to the motion of the slide as the velocity increased. If we assume that this increase in acceleration was due to a diminished coefficient of friction, the value of the coefficient for any time may be found in the following manner:

Let a, b, and h= the altitude, base, and length of the inclined plane.

W= weight of the slide and contents.

W'= normal pressure on the plane, $= W.\frac{b}{h}$.

g= acceleration of a body falling freely.

g'= theoretical acceleration of the slide $=g.\frac{a}{h}$.

g''= the observed acceleration at any time.

Then the resistance of friction $=F=\frac{W}{g}(g'-g'')$, and the coefficient of friction= $\varphi=\frac{F}{W'}=\frac{g'-g''}{g}.\frac{h}{-}=\left(\frac{a}{h}-\frac{g''}{g}\right)\frac{h}{b}=\frac{a}{b}-\frac{g''h}{g\,b}$= tangent of inclination$-\frac{g''h}{g\,b}$.

The following tables give the results obtained from a series

of four experiments. The load in every case was 40 lbs. The inclinations of the plane were as follows: No. 1 =15° 6′, No. 2 =16° 9′, No. 3 =17° 5′, No. 4 =18° 9′.

Table A shows the accelerations corresponding to different velocities in the four experiments. The units used are the $\frac{1}{1600}$ of an inch and the $\frac{1}{433}$ of a second.

TABLE A.

Velocities.	Accelerations. Expt. 1.	2.	3.	4.
4	·020	·033	----	----
10	·035	·056	·073	·092
15	·044	·070	·090	·112
20	·053	·081	·103	·129
25	·059	.083	·112	·140
30	·065	·094	·120	·150
40	·073	·105	·131	·165
50	·078	·112	·140	·176
60	·083	·117	·148	·184
70	·087	·121	·156	·190
80	·091	·125	·159	·196
90	·093	·128	·163	·200
100	·095	·131	·168	·203
110	----	·133	·171	·206
120	----	·136	·175	----

Table B shows the coefficients of friction in each experiment, deduced by substituting the observed accelerations given in Table A in the formula given above. The observed accelerations were of course reduced to feet in a second.

TABLE B.

Velocities.	Coefficients of friction. Expt. 1.	2.	3.	4.
4	·260	·273	----	----
10	·252	·261	·270	·280
15	·245	·254	·261	·270
20	·243	·248	·254	·260
25	·240	.245	·250	·255
30	·237	·242	·246	·250
40	·233	·236	·240	·242
50	·230	·232	·235	·236
60	·228	·230	·231	·232
70	·226	·228	·227	·231
80	·224	·226	·226	·225
90	·223	·224	·224	·223
100	·222	·223	·221	·222
110	----	·222	·220	·220
120	----	·220	·217	----

From the tables it will be observed: 1st. That with a given inclination of the plane, the coefficient of friction decreases as

the velocity increases, rapidly at first but more slowly afterward. 2d. With the same velocity, the coefficient of friction is greater the greater the inclination of the plane, within the limits of the experiments. 3d. The coefficient of friction in each experiment tends toward a constant quantity. 4th. This constant seems to be the same in each experiment.

No simple expression which will show the variations in the coefficient of friction has yet been found; indeed, I have not thought best to attempt to formulate the work till certain errors, which will be referred to, have been corrected. It was found impossible to procure a plank with a perfectly uniform surface. The one used in the experiments given showed at the same inclination and velocity a coefficient which slightly but regularly increased from one end to the other. The end which gave the lower coefficient was placed uppermost. The obvious result of this was to make the coefficients in Table B at high velocities greater than they otherwise would have been. This fact also explains the apparent anomaly in columns 3 and 4 of the same table, where the coefficients at high velocities are seen to fall below the corresponding coefficients in column 2.

In experiment 4 the slide had the velocity 120 at a distance of 40 inches from the upper end of the plane; in experiment 2 it did not acquire that velocity until it had passed over a distance of 60 inches, and consequently was on a rougher portion of the plane. The uniformity of the plane was tested by starting the slide at different points along its length, and comparing the curves on the smoked glass. These experiments have not been corrected for the resistance of the atmosphere. The effect of such a correction would be to diminish still more the coefficients at high velocities.

As the inclination of the plane increases the normal pressure decreases. Thinking that this change of pressure might explain a part of the difference due to a change of inclinations, we made three experiments at the same inclination, with weights of 18, 80 and 140 lbs., in the box. At the end of one second we found the velocities in the three cases to be as 1, 1·18 and 1·32, showing a less resistance in the case of the greater load, and corresponding to a decrease of about 2½ per cent in the coefficient of friction. This seems to be insufficient to explain the change in the coefficient when the inclination of the plane is changed. But it is interesting as showing that in the case of pine on pine friction is not strictly proportional to the normal pressure.

As soon as possible we propose to repeat these experiments, extending the range of velocities, also to try the effect of a change of pressure, with a view to formulate deviations from

the received laws, if simple expressions can be found. We have also designed a modification of apparatus to test our results when a uniform motion is given to the slide.

The experiments in the series (nearly 100 in number) and a greater part of the computations have been very carefully made by Messrs. Butterfield and Wilson, students in the department of Physics.

ART. XXIII.—*On the constitutional formulæ of Urea, Uric Acid, and their derivatives;* by Professor J. W. MALLET, University of Virginia.

FEW classes of organic compounds have given rise to more difference of opinion amongst chemists than that which includes urea and its conjugates.

The remarkable number of such compounds, their complicated relationships, the varied circumstances of their production and decomposition, and their variety of chemical character, have led to nearly every one of them being viewed in several different lights, and represented by several different formulæ, by those who have given the subject special attention.

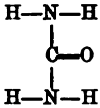
The structure of the simple molecule of urea itself is by no means settled. The arguments of Heintz* and Kolbe† in favor of the view that urea is identical with carbamide ($H_2N—CO—NH_2$) have been opposed by the observation of Wanklyn and Gamgee‡ as to the behavior of urea (unlike that of admitted amides) when oxidized by an alkaline solution of potassium per-manganate. The latter chemists proposed the formula $C\left\{\begin{matrix}(NH)''\\ NH_2\\ OH\end{matrix}\right.$, but, as Watts remarks in his Dictionary of Chemistry,§ without assigning specific reasons (other than the difference of behavior just noted) for adopting this instead of the carbamide formula which they reject. Wolcott Gibbs‖ independently put forward the same view, but *did* give some of the grounds upon which it was adopted by him. It has also been proposed to represent urea as $O=C=NH_2—NH_2$, in which formula one of the nitrogen atoms is pentad. Most recent writers of text-books, however, as Fittig¶ and Naquet,** seem to have fallen back upon the view that urea is simply carb-

* Ann. der Chem. u. Pharm., cxl, 276; cl, 73. † Zeitschr. für Chem., II, iii, 50.
‡ Jour. Chem. Soc., Jan., 1868, 31. § 1st Suppl., 1115.
‖ Amer. Jour. Sci., II, xlvi, 290, Nov., 1868.
¶ Wöhler's Grundriss der org. Chem., 8te. Aufl., 206.
** Principes de Chimie, troisème éd., t. ii, 532–533.

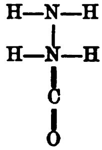
amide. Bunte* has suggested as the means of deciding between these opinions the determination of the maximum number of isomeric products obtainable from the body in question by substituting an alcoholic radical for hydrogen.

The most obvious point of difference between the three formulæ above mentioned consists in the first being symmetrical while the others are not so. If urea be carbonic diamide (1), viz:

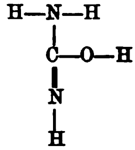
1.



2.



3.



the two nitrogen atoms are placed exactly alike, and so are the four atoms of hydrogen. If the third formula (2) be adopted, the two nitrogen atoms will be unlike, while there will be two pairs of hydrogen atoms with no difference between the members of each pair. But if the formula (3) be the true one, the two nitrogen atoms, while exhibiting the same atomicity, are dissimilarly connected, and hydrogen is found in three different relations to the rest of the molecule, only two atoms of the latter element being quite alike in position. Clearly we should the rather expect from this highly unsymmetrical disposition of the atoms such a number and variety of substituted and conjugated products as urea actually affords.

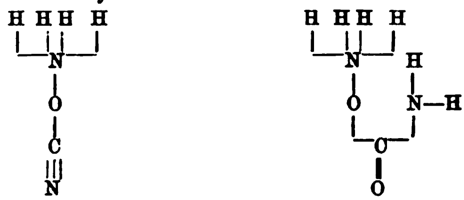
But not only does this last view enable us easily to account for the large class of derivatives furnished by the substance in question, but it seems to lend itself remarkably well to the explanation of the special character which these derivatives severally exhibit, whereas many of the formulæ hitherto proposed for the "ureides" differ much from those of other bodies of the same type, the acid or basic character, degree of basicity, etc., not being satisfactorily accounted for. In this respect Wanklyn, Gamgee and Gibbs seem scarcely to have done justice to the merits of the formula they suggested, and I propose by a few examples of the better known substances related to urea to illustrate the advantages of assuming for it this molecular constitution. In doing so I have to suggest a structural composition for most of the conjugated bodies spoken of unlike that which Gibbs has adopted in the paper above referred to. It will conduce somewhat to clearness to use fully expanded graphic formulæ, and for the conjugated compounds

* Ann. der Chem. u. Pharm., cli, 184.

to use dotted lines to represent the bonds connecting residues derived from different molecules.*

Let then urea be represented by the last formula, No. 3, derivable from ammonium cyanate

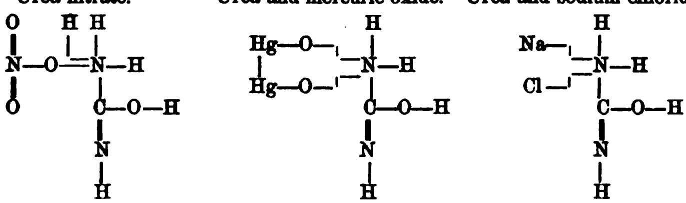
1. Ammonium cyanate. 2. Ammonium carbamate.



by intermolecular transposition, and from ammonium carbamate by change of the same sort with elimination of water. In both cases one of the two nitrogen atoms shows the usual tendency to revert from pentad to triad character by elevation of temperature.

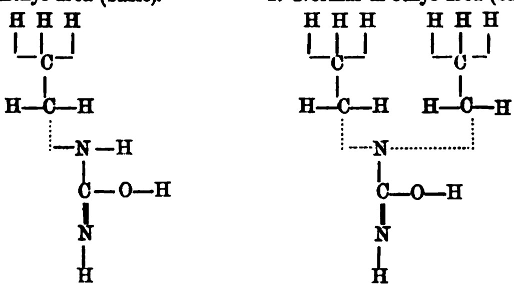
The *direct compounds* of urea (like those of ammonia) with acids involve a re-assumption of pentad relation by this one atom of nitrogen; not by both, as we might expect if they were alike in position in the molecule; as, for instance, in the case of urea nitrate.

Urea nitrate. Urea and mercuric oxide. Urea and sodium chloride.



Similar relations are entered into with some metallic oxides, as for instance, mercuric oxide, and certain salts, as with sodium chloride.

1. Ethyl-urea (basic). 2. Normal di-ethyl-urea (basic).



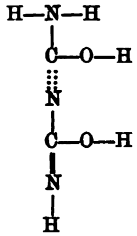
* Some of these graphic formulæ would look rather simpler and better were it not for difficulty on the part of the printer in using *oblique* lines with movable type.

Products of substitution by alcoholic radicals, *in which the urea type and character are preserved*, are exemplified by ethyl-urea, $C_3H_8N_2O$, in which one of the two similarly related hydrogen atoms is replaced, and by normal di-ethyl-urea, $C_5H_{12}N_2O$, in which the replacement extends to both of these atoms. One hydrogen atom of this pair and another (unlike) atom at the same time are probably replaced in the isomeric di-ethyl-urea, and tri-ethyl-urea, if this compound really exist, will represent the replacement of both the similar and one unsymmetric (probably imide) atom of hydrogen.

Formulæ for condensed ureas containing polyatomic radicals, such as ethylene, follow easily enough from the above.

In biuret, $C_2H_5N_3O_2$, we may suppose the residues of two urea molecules united with elimination of ammonia from unlike (amidic and imidic) extremities of the chain of atoms—thus,

Biuret (feebly basic, uniting (by its amidic end probably) with one equivalent of HCl).

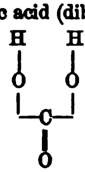


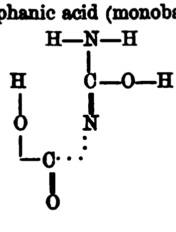
this giving a very obvious explanation of the formation of biuret by heating urea, ammonia being at the same time liberated.

Conjugated compounds of urea residues and acid radicals form a more numerous class. In these the type of the original acid seems usually to predominate, but *the urea residue modifies the character of the substance in different ways according to the mode of attachment.* This last point seems to have been the chief one overlooked in the arrangement of most of the structural formulæ hitherto proposed.

Thus, from carbonic acid, CH_2O_3 (di-basic), we get allophanic acid, $C_2H_4N_2O_3$,

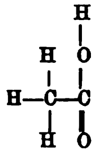
Carbonic acid (dibasic). Allophanic acid (monobasic).



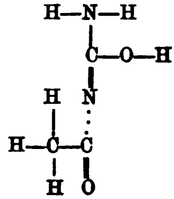


only one of the two basic hydrogen atoms present in the original acid remaining in place. A comparison of allophanic acid thus viewed with the above formula for biuret will show how the latter is produced by the action of ammonia upon ethyl allophanate. From acetic acid, $C_2H_4O_2$, we have acetyl-urea, $C_3H_6N_2O_2$ (exhibiting neither acid nor basic character),

Acetic acid (monobasic).

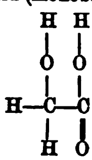


Acetyl-urea.

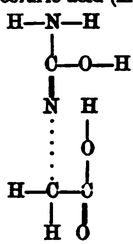


the one basic atom of hydrogen of the original acid having been replaced by the urea residue at its imide extremity. From glycollic acid, $C_2H_4O_3$, we have glycoluric (hydantoic) acid, $C_3H_6N_2O_3$.

Glycollic acid (monobasic).

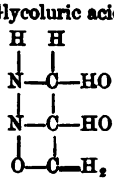


Glycoluric acid (monobasic).



the urea residue replacing the methylic hydroxyl, while the original oxatyl remains unaffected and the acid character is preserved. In the formula for glycoluric acid proposed by Gibbs, viz: (misprinted in his paper in the transposition of the — and ═ in the bottom line):

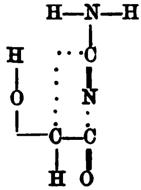
Glycoluric acid.



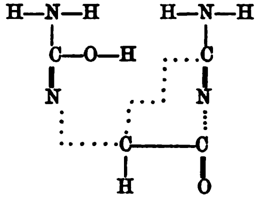
the mono-basic character is not obvious, nor does it readily appear which is the replaceable (basic) atom of hydrogen.

If glycollic acid be differently conjugated with urea, the residue of the latter attaching itself in place of the *basic* hydroxyl, and a molecule of water being eliminated, we get hydantoine, $C_3H_4N_2O_2$ (1).

1. Hydantoine (neutral).

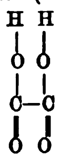


2. Glycolurile (neutral).

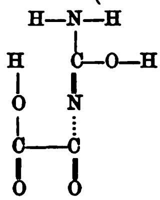


By reference to the formula proposed further on for allantoine it will be seen how simply the production from it of hydantoine occurs with separation of urea. Glycolurile, $C_4H_6N_4O_2$, appears (2) as the corresponding di-ureide of glycollic acid, and its relation to allantoine (from which it is producible by the action of sodium amalgam) will be easily seen by reference to the formula for the latter, although I prefer to view these bodies as derivatives of two different acid nuclei. The breaking up of glycolurile by an acid in the presence of water into hydantoine and urea is easily traced. From oxalic acid, $C_2H_2O_4$, we get oxaluric acid,* $C_3H_4N_2O_4$,

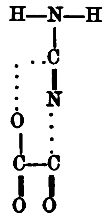
1. Oxalic acid (dibasic).



2. Oxaluric acid (monobasic).



3. Paraban.



easily breaking up in presence of water into oxalic aci(..nd urea.

The absence of well determined acid character in paraban (parabanic acid), $C_3H_2N_2O_3$, justifies the above formula, No. 3, which well explains Ponomareff's† synthesis of this body by the action of phosphorus tri-chloride on a mixture of oxalic acid and urea, as well as the ready conversion into oxaluric acid by assumption of water; while the so-called metallic salts formed by this body (including those described by Menschutkin),‡ remarkable for their instability, may probably represent merely the substitution of amidic hydrogen in the urea residue, as cholestrophane results from the substitution of both these hydrogen atoms by methyl. It will be seen presently that this formula makes paraban bear exactly the same relation to oxalic acid that alloxan does to mesoxalic acid.

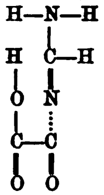
* There is some misprint in the formula for this acid in the memoir of Gibbs (loc. cit., p. 292), since it contains an atom of oxygen too much.

† Bull. Soc. Chim. de Paris, II, xviii, 97.

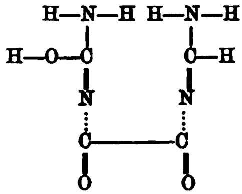
‡ Ann. der Chem., clxxii, 73.

If in the ureic residue of oxaluric acid we substitute hydrogen for hydroxyl, we get the formula for allanturic (lantanuric) acid, $C_3H_4N_2O_3$,

1. Allanturic acid (monobasic).

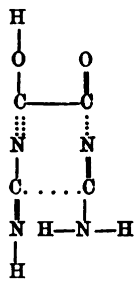


2. Allantoine (neutral).



and the mode in which this acid is produced from allantoine by assimilation of water and separation of urea becomes evident if we give to allantoine, $C_4H_6N_4O_3$, the following formula (2), viewing it as a di-ureide derivative of oxalic acid, with which it appears in fact to be closely connected, producing oxalates by heating with alkaline solutions, by fermentation with yeast, &c. By reference to the formula proposed further on for uric acid it will appear how this latter yields allantoine on boiling an aqueous solution with lead dioxide, the middle carbon atom of the mesoxalic acid residue being removed as carbon dioxide, and hydroxyl and hydrogen respectively taken up from a molecule of water by the two ureic residues, which at the same time assume a different mode of attachment to the oxalic acid nucleus; the further action of an excess of lead dioxide decomposing the allantoine itself, with formation of urea and lead oxalate. The formula of Gibbs for allantoine (as for hydantoine and glycolurile) would lead us to expect an acid character, whereas such compounds as are formed by this body with metals and metallic oxides manifestly are of the same order as those produced with similar substances by urea itself. In the other di-ureide, viz: mycomelic acid, $C_4H_4N_4O_2$,

Mycomelic acid (monobasic).

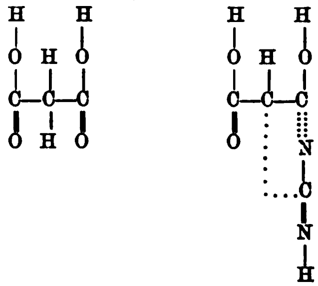


we have an example of what I agree with Professor Gibbs in assuming as very probable, namely, the similarity of function

of nitrogen with two free bonds to the outside oxygen in oxatyl,* so that I represent one of the two such oxygen atoms in oxalic acid as replaced by a urea residue connecting itself by its amidic extremity, the hydrogen of the corresponding hydroxyl of the acid retaining its basic character; while the second residue of urea, attached by the opposite end of its chain of atoms, replaces hydroxyl instead of oxygen, and thus changes a di-basic into a mono-basic acid. Here we have an instance of what seems to me the error arising in many of the older formulas from considering merely the number of atoms, with their additions or subtractions, without noticing the character of the compounds in question as an indication of molecular structure. Odling† says of mycomelic acid that it bears "exactly the same relation to oxalic acid that uric has to mesoxalic acid." So it does, in so far as the summation of the atoms present is concerned, but the two last named acids are both di-basic, while oxalic and mycomelic acids are di-basic and mono-basic respectively. It will be seen presently that the formulæ I propose account fully for this, the two urea residues in uric acid being similarly connected with the residue of the original acid, while in mycomelic acid they are connected by what I have called the amidic and imidic ends respectively.

Passing to the 3-carbon acids, from malonic acid, $C_3H_4O_4$, No. 1, may be derived barbituric acid, $C_4H_4N_2O_3$, No. 2.

1. Malonic acid (dibasic). 2. Barbituric acid (dibasic).



Gibbs' formula (in which there is a trifling misprint) would imply a mono-basic acid.

Naquet‡ speaks of "l'hydantöine, qui représente de l'acide allanturique moins un atome d'oxygène, et qui est, par conséquent, à l'acide allanturique ce que l'acide barbiturique est à l'acide dialurique." But of these two pairs of substances,

* As in the polymerides of true cyanic acid. Prof. Gibbs proposes to call (CNOH)″ cyanyl, as analogous to (COOH)′, oxatyl.

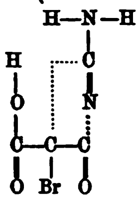
† Lectures on Animal Chemistry, London, 1866, p. 132.

‡ Principes de Chimie (1875), ii, 578.

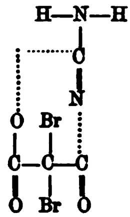
hydantoine is neutral, and allanturic acid a mono-basic acid, while barbituric and dialuric acids are di-basic and mono-basic respectively. The formulæ proposed in this paper furnish an explanation of the difference.

Any formula I have seen for bromo-barbituric acid, $C_4H_3BrN_2O_3$, would lead one to expect for it exactly the same degree of basicity as that of barbituric acid. But the following (No. 1) with the urea residue oppositely attached) will show how the former acid is mono-basic, while the latter is di-basic.

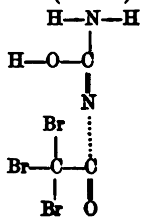
1. Bromo-barbituric acid (mono-basic).



2. Brom-alloxan or di-bromo-barbituric acid (non-acid).



3. Tri-brom-acetyl-urea (neutral).

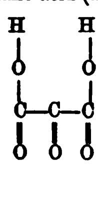


A further replacement of hydrogen by bromine gives us what has been called di-bromo-barbituric acid, $C_4H_2Br_2N_2O_3$, a body which is, however, really devoid of acid character, not forming salts. With the formula now proposed (No. 2, above), this non-acid character becomes intelligible, and the name brom-alloxan, originally employed by Baeyer, becomes fully justified on comparison with alloxan as represented further on. The conversion of this body into dialuric acid by the action of hydro-sulphuric acid in the presence of water is explained by the formula for dialuric acid given further on.

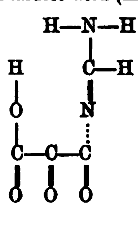
On pushing the action of bromine still further, brom-alloxan is converted, with separation of carbon dioxide, into tri-brom-acetyl-urea, $C_3H_3Br_3N_2O_2$ (from the 2-carbon acid residue), the formula of which (No. 3, above) is very simply derived from No. 2, and brings us back to that of acetyl-urea as already given.

From mesoxalic acid, $C_3H_2O_5$ (No. 1), we get the acid mon-ureide dialuric acid, $C_4H_4N_2O_4$ (No. 2),

1. Mesoxalic acid (di-basic).



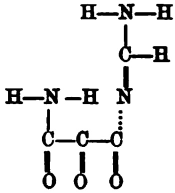
2. Dialuric acid (mono-basic).



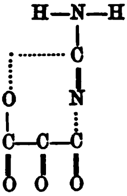
in which the ureic hydroxyl is replaced by hydrogen. The production of this acid by hydrogenation of alloxan will be seen presently to be readily intelligible.

And from dialuric acid is derived the amide, uramile (dialuramide), $C_4H_5N_3O_3$ (No. 1).

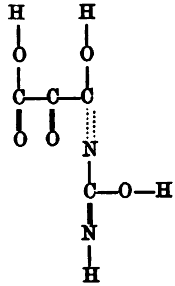
1. Uramile (neutral).



2. Alloxan (neutral).



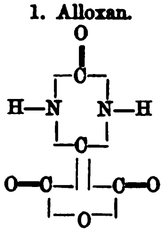
3. Alloxanic acid (di-basic).



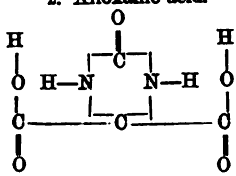
For the production of this body from alloxantine by the action of ammonium chloride, with separation of alloxan and hydrochloric acid, see the formula given beyond for alloxantine.

The formula of alloxan, $C_4H_2N_2O_4$, also a mon-ureide, becomes as represented in No. 2, while alloxanic acid, $C_4H_4N_2O_5$, formed by attachment of the urea residue by its opposite extremity, and with assumption of a molecule of water, may be viewed as in No. 3 above. Claus and Emde* have noticed the difference of character between the last two substances, and suggested in explanation the following formulæ:

1. Alloxan.



2. Alloxanic acid.



one of the few instances in which I find an attempt made to carry out the idea urged in this paper. Gibbs's formulæ would imply that both substances were acid, and of the same degree of basicity. The parallelism between alloxan and paraban is seen to be brought out by the mode of representation now suggested, and an explanation is afforded of the fact that whereas, as Naquet† says (looking only at the number of atoms concerned), alloxanic acid bears the same relation to alloxan that oxaluric acid does to paraban, the former acid is di-basic and the latter mono-basic only.

* Ber. d. deutsch. chem. Gesellsch., vii, 226. † Principes de Chimie (1875), ii, 578.

(To be continued.)

ART. XXIV.—*On Flint-implements from the Stratified Drift of the vicinity of Richmond. Virginia;* by CHARLES M. WALLACE.

THE James River, upon the left bank of which Richmond is situated, approaches the city from the southwest—running in the Mannikin country over fields of bituminous coals, and pouring its waters in headlong rapids over a broad belt of granite, through which it has cut a channel sixty feet or more deep. Huge bowlders, some of them weighing many tons, crowd the drift-beds near the falls, and strew the surface of the uplands below them. Many of those which were in the way of the early settlers have been broken up and removed, but others that remain, sufficiently indicate the course and level of the Drift. In some instances that I have noted, the marks of ancient pot-holes are legibly impressed upon them, proving unmistakably the fact of their descent from the rapids above.

The trend of the prehistoric river is distinctly traced on its south side by the great upper terrace, which probably formed one of its borders before the bed-rock on the Richmond side had been scooped out. As far as I have explored this even and lofty plane—say twenty miles up the basin—it appears to be capped on its inner slope with gravel of the same general character as that which has been excavated at corresponding levels on the opposite shore. A succession of parallel slopes of limited extent show how the current has been diverted from a straight-forward course, and how, upon approaching the tide-water, it has slid away to the north side, forming a wide horseshoe of several miles in extent.

The shelving of the left bank with its relief of hills is quite in contrast with the picturesque island-terraces upon which the neighboring city of Manchester is built. Main street in Richmond runs through the center of the drift-field which abuts upon the steep sides of the city hills, and converges to a point before being swept by the freshets of Gillies Creek and James River. It is on the exposed flank of this field that I have found some of the best specimens of drift-flints in my collection.

My first discoveries were made a little more than a year ago in the elevated beds of the Appomattox, below its falls, and in the brick-earths that uniformly overlie the drifts of this valley.

One of the implements I extracted from a deep bed of brick-clay on the left bank of James River, which has been recently cut away for an avenue to the Free Bridge; it was firmly imbedded in the stiff clay—on its flat side—about seven or eight feet below the surface of the terrace, which at this point attains an elevation of forty or more feet above the rapids. It is of

clay-slate, and has the ordinary English hatchet-like shape, with slight chippings at its lower cutting-edge, but no side-grooves for the clasp of a handle. The drift-bed, as evidenced by bowlders of granite and thin seams of pebbles interspersed through the clay, lies at a distance of 300 yards from the river, upon a sloping trough of the granitic rock.

My next discoveries were made in the clay and gravel of the famous Powhatan terrace. This upland has been to me a prolific field for the finding of palæolithic implements. It may be cursorily described as a shelf-like bank on the north side of the James River, at the lower turn of the horseshoe, three-quarters of a mile long by one-third of a mile in breadth. It rises in bluff-like style from the river—with its upper surface at least thirty feet above the ordinary flooding of the tide. For many years the top clay has been used by brick-men who find the bed thicker as it recedes from the bluff and approaches the hills. The following is a section of this shelf-terrace near the river, where the strata appear to lie conformably.

	Feet.
1. Top soil, with occasional bowlders,.........	0·6
2. Brick-earth, yellowish hue,.................	3
3. Whitish clay, hard and stiff when dry,.....	6
4. Old river gravels, large pebbles at base,.....	7
5. Gray-brownish sand compacted, resting upon Tertiary earth, depth not ascertained.	

This gives a fair idea of the terrace along its river-front, which has been excavated for a railway, say half a mile or more.

In the angle formed by the river and Almond Creek, a wide area of the terrace has been laid bare, exposing to view some interesting features of the Drift. The Old River gravel has been shaved off a little below its surface—as much as 450 feet long by 150 feet wide. A large bowlder of quartz, and several bowlders of granite rest upon beds of reddish, rounded gravel, giving the air of having been transported hither by floating ice, and deposited in gentle waters. One of the larger group measures eight feet one way by twelve the other, and still bears upon one of its sides the mark of an ancient pot-hole. The elevation of this excavated bed above the tide—a few yards distant—is about twenty-four feet.

Carefully inspecting the upright walls on either hand, I found, *in situ*, at a depth of four feet below the surface, the implement which is described below. It was lying at the base of the brick-clay—which here is very scant—on its flat side, as if it had been dropped in the ooze of the marsh mud. Indeed the color is not of the earth from which it was taken, but whitish or porcelaneous, like pebbles from the spring gravel.

It has been split in two by a single blow of the workman's hammer along its longer axis. There are two clearly-marked side-grooves obviously designed for being wrapped by withes or fastened in a haft. The fractured face has been worn a little less smooth than the natural crust of the pebble, and the flakings at the sides and edges look worn as if by being rubbed in gravelly beds.

This implement does not materially differ, except in the peculiar coloring of its outside, from some in my collection from the surface. I regard it as a most interesting specimen from the drift, as it appears to link the discoveries of the older gravels with those of the immediate surface. Two other strange-looking tools were taken by me from the gravel four and eight feet below the surface. Both of them are hoe-like in structure. From the dumps which serve to ballast the track of the railway, I picked up quite a number of worked pebbles, which evidently came from this bed.

Lest I might be deceived as to the archæological value of these discoveries, I requested Judge Clopton, who had manifested a warm interest in my researches, to accompany me on my next excursion.

The next field selected lay along the bluffs of the river, and on either side of the York River Railroad. At the north side of the Yuengling Brewery, immediately overlooking the tide, we picked from the old river-gravels several flint-chips, but no well-defined forms. Below this point a few paces, I had previously picked out of a gully a beautiful disk of quartz, which, being crusted with the bowlder clay, I concluded belonged to a bed of that formation close by. It was originally a flat, round pebble, which had been struck into its present form by a skillful hand. The face which retains the natural crust, suggests the idea of its having been flattened by grinding ice under heavy pressure. One third of its periphery has been chipped to a sharp, jagged edge, as if for the purpose of barking trees or bruising bones. It may have been hafted—but it is more likely that it was used directly by hand. It is a little larger and thicker than a biscuit of hard tack.

The most important discovery of the day's excursion was reserved for the close. A few paces below Main street, in a deep cut of the York River road, and high above the highest water-mark of the river, among many imperfect indications, Judge Clopton was the first to notice a brownish looking flint, stuck fast in the cemented gravel, eight feet below the surface. It was lying with its point on a downward slide, as if it had acquired that position by a landslip over the Tertiary beds.

The shelf of land, from which this unique spear-head was taken, is distant about 150 yards from the river-shore, and

forms the extreme or turning point of the Richmond terrace. The height of the gravel-bed above the tide is forty feet or more.

A few days later I inspected alone the Richmond terrace on its bluff-side, near the Dock, from which I have received some of the most interesting relics of the Quaternary man of Virginia. The order of the formation at this point appears to be:

	Feet.
1. Brick-earth underlying grayish clay,........	9
2. Rounded gravel, reddish hue,...............	4
3. Deposit of fine bluish sand,.................	12
4. Bed of gravel and bluish pebbles,...........	4
5. Alternate seams of compacted sand, gray and yellow, above the level of base of excavation,	4
Depth of formation as far as known,.....	33

The brick-earth of this section of the terrace has been topped off to allow of the extension of Cary street, and the natural wall has been pushed back, so to speak, as much as fifty feet or more, to make room for the foundation of the York River Railroad Station. From the surface of the lower gravel bed, I extracted several worked flints, two of which closely resemble those of the European Drifts. A remarkable feature of the lower seam of gravel is the presence in large numbers of the pebbles from which the implements for the most part appear to have been fashioned.

One of them is somewhat like an implement from the Reculver Pits, a sketch of which may be seen at page 534 of Mr. John Evans's elaborate work on The Ancient Stone Implements of Great Britain. The other is of lanceolate form, and will be readily recognized by those familiar with the relics of the Caves and Drifts of the old world. It is much worn by long association with the older gravels. It was probably used as a scraper.

Deeming such discoveries of interest to the scientific world, I lost no time in reaching its ear, through the medium of Professor Spencer F. Baird, who very readily acknowledged my labors, in the most cordial and encouraging way.

I have extended my inquiries farther away from the river, with continued success. The Great Upper Southside Terrace already referred to, has been recently explored by me, and found to contain worked pebbles of the same general character as those derived from the high-level gravels on either side of James River.

An excavation eight feet deep has been made on the inward slope of this old river-shore disclosing fine and coarse gravel intermixed with reddish clay. The field of the surface below this excavation has afforded many similarly worked peb-

bles—which circumstance favors the conjecture that they have been washed out of the overlying beds.

I dug out of the vertical wall of excavation two well-defined implements—one three feet below the surface, the other two feet deeper. Both were imbedded in firmly cemented reddish gravel. The deeper-lying pebble is worn smooth on its chipped edge, the other has the appearance of being rolled but slightly.

This section of the old-river shore is half a mile distant from the present bank of the river. I may hereafter refer to it as the Fonticello gravel. Similar beds of gravel on the right bank of the river I have found to contain worked pebbles.

Mr. Mann S. Valentine, to whom I have shown my drift-specimens, has examined a bed of old river-gravel a mile away from the falls, and found some interesting flints. I have not seen them, but do not doubt that they are of the same general character as those contained in the high-level beds on either bank of the river.

In a deep cut of the Petersburg road, a little beyond the High bridge on the south side, I found several flint chips and worked pebbles, which appear to take the staining of the light gray matrix from which they had been taken. The elevation of the terrace at this point is seventy feet above the rapids—the depth of the specimens below its surface ten feet. My son Charles, who has been trained to look for worked flints, dug out of the clay-bed a rude stone hatchet. An exceedingly beautiful adze or hatchet was found here by me, though not in place. There can be no doubt that it belongs to the same stratum of clay from which other but not similar looking flints were extracted by me. It is shoe-shaped grayish-looking quartzite flint, and has been chiseled into form by a half dozen blows given with a downward stroke. It is not worn. It may have been used either in the hand, or with a haft.

The whitish clay from which I took it lies in a trough of the granite which attains an altitude at this point of sixty feet or more above the level of the river close by. It is capped by the usual brick-earth, which, however, is rather scantily deposited at this place.

It will be understood by the reader that all the discoveries herein mentioned were made in deposits forming parts of the clay and gravel. The implements could not have been introduced into the formations by any other agencies than those which deposited at the same time the containing beds.

Richmond, Va., Jan. 13, 1876.

Art. XXV.—*Description of a new Trilobite, Dalmanites dentata;* by Dr. S. T. Barrett.

The Trilobite described below is from the upper compact beds of the Delthyris shale, a member of the Lower Helderberg formation, near Port Jervis, Orange County, New York. The name, *Dalmanites dentata*, refers to the dentate margin of the cephalic shield. The following are its characters.

Dalmanites dentata.—Outline of head parabolic; posterior side concave, and posterior angles prolonged into mucronate, slightly falcate extensions; its outer margin throughout dentate. Eyes having about the same position as in *D. pleuroptyx*, but nearer the outer margins of the cheeks because of the less breadth of the head; number of lenses in a large specimen about 180, eight ranges of them on the highest side. Pygidium triangular, transversely convex; posterior extremity prolonged into a gradually attenuate spine, which is a continuation of the lateral margin, and averages half the length of the axis. Axis sloping evenly throughout, its inferior extremity nearly merged in the border below. Two rows of minute spines extending the entire length of the axis near its center, and scattering minute spines either side over the surface of the segments.

Fragments of what I suppose to be thoracic segments of this species are common. Each terminates laterally in a slender terete spine curved outward and upward at right angles to the rest of the segment; it has a deep narrow longitudinal groove upon its lateral portion, which runs out backward toward the spine, and a deeper transverse groove over its middle portion, the part posterior to which is much larger than that anterior; the surface has minute spines, and otherwise resembles that of the pygidium.

This species has a considerable vertical range, and some layers of the rock are mainly made of its remains. It is associated with *Rensselaeria mutabilis*, *Homalonotus Vanuxemi*, *Loxonema Fitchiana*, *Chonetes complanata*, and other Lower Helderberg species, kindly identified for me by Professor Hall.

The excellent photograph illustrating this paper was taken, from one of the best of my specimens, by the skillful photographer of Port Jervis, Mr. E. P. Matterson. It is one and a half times larger lineally than the specimen. The writer will furnish those desiring it a second photographic plate, giving a view of the pygidium, eye prominence, and thoracic segment, and has specimens for exchange.

Port Jervis, Dec. 29, 1875.

ART. XXVI.—*Mineralogical Notes;* by EDWARD S. DANA. No. II.—*On the Samarskite of Mitchell County, North Carolina.*

THROUGH the kindness of Mr. Joseph Willcox of Philadelphia, and of Rev. J. Grier Ralston of Norristown, I have had an opportunity of examining a considerable number of more or less perfectly crystallized specimens of samarskite, which belonged to their cabinets. The results are sufficiently definite to give a pretty exact knowledge of the relations of the species which have been till now very uncertain.

According to information obtained from Mr. Willcox, and also from Professor Bradley, the samarskite is found in the mica mines situated in the mountains of Mitchell County, North Carolina. The rocks of the region are gneiss and mica slate, and the mines are worked in the granite veins which intersect them. Other localities also exist, under similar circumstances, in Yancey, McDougal and Rutherford Counties. The samarskite occurs in masses, generally irregular in shape but sometimes coarsely crystallized, imbedded in a reddish feldspar, which is very much decomposed, sometimes to a kaolin. The masses vary in size, some being very large; one obtained by Mr. Willcox weighed upwards of twenty pounds.

The immediately associated minerals are two other species of the same tantalic group, described further on, and a yellow mica, which may prove upon chemical examination to be of interest.

The samarskite when pure has a deep velvet-black color, though brown by transmitted light on very thin edges. The luster is resinous and very brilliant, and the fracture distinctly conchoidal. The mineral from this locality has already been analyzed by Miss Ellen H. Swallow,* with the following results (specific gravity 5·755): Metallic acids, tantalic group, 54·96, SnO^2 0·16, UO 9·91, FeO 14·02, MnO 0·91, CeO 5·17, YO 12·84, MgO 0·52, insoluble residue from oxalate of cerium 1·25, ignition 0·66 = 100·40. The metallic acids were not separated in consequence of the want of material. Attention may also be called here to the analysis, by Dr. Hunt, of the samarskite from Rutherford County, N. C., published in this Journal, II, xiv, 341, 1851.

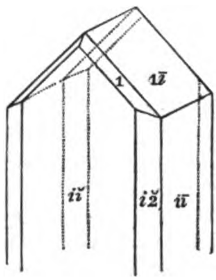
The samarskite exists in all states of purity, being sometimes intimately mixed with the gangue of decomposed feldspar. There are also connected with it several more or less distinct decomposition-products which deserve a chemical examination. A yellow coating over the surface of the masses is very com-

* Proceedings of the Boston Society of Natural History, vol. xvii, 424, 1875.

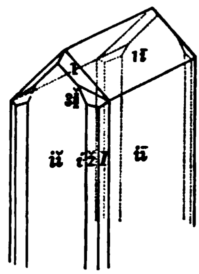
mon; and in some cases the exposed exterior of the pure mineral has taken a chocolate-brown color.

As has been stated, indistinct crystals and crystalline masses are not uncommon, and some few specimens, especially those placed in my hands by Mr. Ralston, admitted of exact determination. The general habit, and the more common of the occurring planes are shown in figure 1, the additional planes of figure 2 are rather rare.

1.



2.



The characteristic feature of all the crystals, almost without exception, is the nearly right-angled edge between the macrodomes, $1\text{-}\bar{i}$. Not infrequently the elongation of this terminal edge gives the crystals a prismatic appearance in that direction. More generally, however, the crystals are elongated vertically in the direction of the prism as taken in the figures; a radiated arrangement in the groupings of the crystals, sometimes observed, is a feature deserving mention. The prismatic planes (I and $i\text{-}\breve{2}$) are in all cases narrow so that the general habit is that of a rectangular prism; frequently the crystals are flattened in the direction of the brachypinacoid $i\text{-}\breve{i}$, and upon the surface of this plane are sometimes observed a number of small outlined crystals similar to those often occurring on the diametral planes of columbite. Occasionally, also, $i\text{-}\bar{i}$ is the more prominent, giving rise to forms flattened in this direction.

The occurring planes, as seen in the figures, are as follows: $i\text{-}\bar{i}$, $i\text{-}\breve{i}$, I, $i\text{-}\breve{2}$, $1\text{-}\bar{i}$, 1, $3\text{-}\breve{\tfrac{3}{2}}$. The planes are without luster and often quite rough, so that approximate measurements alone were possible; and in different crystals some of these angles varied considerably. The angles obtained from the best formed crystals are as follows:

$$i\text{-}\breve{2} \wedge i\text{-}\breve{2} = 95^\circ;\ 1\text{-}\bar{i} \wedge 1\text{-}\bar{i} = 93^\circ.$$

From these measurements the following axial ratios are obtained:

$$c' \text{ (vert.) } 0{\cdot}949,\ \bar{b} \text{ (macr.) } 1{\cdot}833,\ \breve{a} \text{ (brach.) } 1{\cdot}000.$$

Some of the calculated angles for the other forms are as follows, the angles obtained by measurement being given in parentheses:

$I \wedge I = 122° 46'$, $I \wedge i\text{-}\bar{i} = 151° 23'$ (152°), $i\text{-}\breve{i} \wedge 1 = 110° 35'$ (110°), $i\text{-}\bar{i} \wedge 1 = 130° 7'$, $I \wedge 1 = 137° 14'$, $i\text{-}\breve{i} \wedge 3\text{-}\breve{\frac{3}{2}} = 125° 55'$ (126°), $i\text{-}\bar{i} \wedge 3\text{-}\breve{\frac{3}{2}} = 135° 46'$ (136°).

The position here adopted shows most favorably the probable relation of the samarskite, of North Carolina, to the crystals of yttrotantalite described by Nordenskiöld.

	Samarskite (Dana).	Yttrotantalite (Nordenskiöld).	Columbite.
$I \wedge I$	122° 46′	123° 10′	(122° 48′, $i\text{-}\bar{\frac{3}{2}}$)
$i\text{-}\breve{2} \wedge i\text{-}\breve{2}$	95°	94° 32′	(94° 58′, $i\text{-}\breve{\frac{4}{3}}$)
$1\text{-}\bar{i} \wedge 1\text{-}\bar{i}$	93°	(87° 24′, $\frac{1}{2}\text{-}\bar{i}$)	90° 15′
$i\text{-}\breve{\frac{3}{2}} \wedge i\text{-}\breve{\frac{3}{2}}$	(101° 24′)	(101° 52′)	101° 26′ (I)

The parentheses indicate that the forms referred to have not been observed. The pyramidal planes of samarskite (1 and $3\text{-}\breve{\frac{3}{2}}$) are not known on yttrotantalite. It will be observed that while in the prismatic zone the agreement between the two species is close, in the domes the variation is considerable.

The prism of samarskite referred to the axes of columbite (Dana's Min., p. 516) is $i\text{-}\bar{\frac{3}{2}}$, and on this basis the other planes become as follows: $i\text{-}\breve{2} = i\text{-}\breve{\frac{4}{3}}$, $1 = 1\text{-}\bar{\frac{3}{2}}$, $3\text{-}\breve{\frac{3}{2}} = 2$, $1\text{-}\bar{i} = 1\text{-}\bar{i}$.

The crystalline form of euxenite has not been very clearly made out, but it seems to be closely related to that of samarskite; for $I \wedge I$, Dahl gives 126°, Greg 120°? (122° 46′ samarskite); $i\text{-}\bar{i} \wedge m\text{-}\bar{i} = 154\frac{1}{2}$ and 153°, but $i\text{-}\bar{i} \wedge 2\text{-}\bar{i} = 152° 13'$ (samarskite); also two pyramids are mentioned giving the angles $i\text{-}\breve{i} \wedge p^1 = 107$ ($i\text{-}\breve{i} \wedge 1 = 110° 35'$ samarskite), $i\text{-}\bar{i} \wedge p^2 = 136°$ (135° 46′ samarskite).

The method of association of crystals of samarskite and columbite at Miask (to be mentioned later) seems to suggest that the broad plane, $i\text{-}\breve{i}$ of the figure, may possibly correspond to the plane $i\text{-}\bar{i}$ of columbite. (To avoid confusion it must be noticed that $i\text{-}\bar{i}$ columbite, Dana's Mineralogy = $i\text{-}\breve{i}$ Naumann, and I Dana = $i\text{-}3$ Naumann.) This idea is supported by a single one of the specimens under examination, where of two associated crystals, the cleavage plane (probably $i\text{-}\bar{i}$) of the columbite was exactly parallel with the plane of the samarskite called $i\text{-}\breve{i}$ above. If now this change is made, the planes, before mentioned, become as follows: If $i\text{-}\breve{2} = I$ and $i\text{-}\breve{i} = i\text{-}\bar{i}$ then $I = i\text{-}\breve{2}$, $1 = 1\text{-}\breve{2}$, $3\text{-}\breve{\frac{3}{2}} = 2\text{-}\breve{\frac{4}{3}}$. The consideration of all the facts, however, seems to show that the method first proposed should be adopted.

It may also be mentioned here that several of the minerals of this group show angles of 91°–95°, 128°, etc., in the prismatic zone, although in the other zones there is no apparent correspondence, and the habit is quite different.

The occurrence of two other minerals of this tantalic group has already been mentioned. One of these minerals occurs in regular octahedrons, sometimes nearly an inch across, with the

cubic planes, and also the form 3-3. It has a yellowish-brown color and resinous luster. Professor Brush reports, from his examination, that in blowpipe characters it agrees closely with pyrochlore; but its specific gravity as determined by him on a pure crystal is 4·794, which is considerably higher than that of pyrochlore (4·203, Hermann), so that it may approach more nearly to microlite. For a definite knowledge of its character we must consequently wait for the chemical analysis which Professor Allen proposes soon to undertake. These octahedrons occur generally in a rusty gangue, the mass of which seems to consist mostly of the same mineral. They are also sometimes observed implanted directly upon the samarskite.

The second associated mineral is *columbite*. It occurs in crystalline masses of considerable size, imbedded in the samarskite, or implanted upon it. The form where distinct is very similar to those given in Dana's Mineralogy, figures 429, 430, p. 516, and the angles agree closely. From some qualitative experiments Professor Allen finds that it contains a considerable quantity of tantalic acid. On this account it is a matter of some surprise that its specific gravity is only 5·476.

This intimate association of columbite and samarskite at this locality is the more interesting in that, as long ago shown by Hermann, these two species occur together at Miask in the Urals. Some Uralian specimens recently examined by me have the minute crystals of columbite, well formed, implanted on the samarskite, the crystals of the two appearing to occupy a parallel position. It would here hardly be suspected that the two minerals were distinct, except from the cross fracture, in which the two decidedly differ. The American specimens, on the other hand, with the single exception alluded to, show no relation at all in the position of the crystals of the two species.

Professor Allen is at present engaged in a thorough chemical investigation of the various minerals, which have been mentioned, and the results of his work will be awaited with much interest.

ART. XXVII.—*The Effect of Silicic Acid upon the Estimation of Phosphoric Acid by Ammonium Molybdate;* by E. H. JENKINS.

THE idea seems to be general that the presence of silicic acid in solutions, impairs the accuracy of the estimation of phosphoric acid by the molybdic method. In Rose's Handbuch der Analytischen Chemie, 6th edition, volume ii, page 519, under a description of this method the fact is stated that silicic acid gives a precipitate similar to the ammonium

phospho-molybdate, and Fresenius (Quantitative Analyse, 5th edition, page 334) advises the separation of silicic acid as a preliminary. W. Knop has observed (Chemisches Centralblatt, 1857, page 691) that ammonium molybdate, added to a solution containing silicic acid and a large quantity of ammonium chloride, produces a lemon yellow precipitate much like ammonium phosphomolybdate. Without this excess of ammonium chloride no such precipitate forms, either in the cold or after heating to boiling.

It might readily be supposed, however, that, though not precipitated by itself with ammonium molybdate, silicic acid could come down in a precipitate of ammonium phosphomolybdate and introduce an error. To ascertain whether this actually happens the following experiments have been made. A solution of potassium silicate was employed, made by boiling pure silicic acid with potassium hydrate, and acidifying slightly with nitric acid. It contained in 50 c.c. ·2055 grs. of silicic acid, and bare traces of phosphoric acid. A solution of pure hydrodisodic phosphate was prepared, and the phosphoric acid estimated by the ammonium molybdate method. 25 c.c. gave

(1) ·0844 $Mg_2P_2O_7$ = ·05398 P_2O_5
(2) ·0845 " ·0540 "

Estimations of phosphoric acid were made in varied quantities of the solution of sodium phosphate with the addition of potassium silicate, by the molybdic method.

The amounts of the solutions employed and the results obtained are given below.

·0492 SiO_2	+ 1 c.c. sodic phosphate	= ·0022 P_2O_5	gave	·0023 P_2O_5
·0492 "	+ 5 "	= ·0108 "	"	·0114 "
·0492 "	+ 12·5 "	= ·0270 "	"	·0267 "
·0123 "	+ 25 "	= ·0540 "	"	·0540 "
·0246 "	+ 25 "	= ·0540 "	"	·0545 "
·0492 "	+ 25 "	= ·0540 "	"	·0544 "
·2055 "	+ 25 "	= ·0540 "	"	·0538 "
·2055 " ·5000 $CaSO_4$ ·2000 MgO ·5000 Fe_2O_3 1·0000 Alum	+ 25 "	= ·0540 "	"	·0544 "

A solution of tricalcic phosphate in nitric acid containing in 50 c.c. ·0379 grs. P_2O_5 gave with ·3100 SiO_2 ·0381 grs. P_2O_5

$$\left.\begin{array}{l}\cdot 3100\\ 1\cdot 0000 \text{ alum}\end{array}\right\}\text{gave } \cdot 0382 \text{ grs. } P_2O_5$$

The ammonium molybdate and magnesium chloride solutions used in these determinations were made as recommended

by Abesser, Jani and Märcker in their paper on the estimation of phosphoric acid (Fresenius Zeitschrift, 12th year, p. 252), and all the operations were conducted as there advised. The above results show that in no ordinary case is a previous separation of silicic acid necessary to ensure all desired accuracy in the estimation of phosphoric acid by the molybdic method.

Prof. Kolbe's Laboratory, Leipzig, Dec. 17, 1875.

ART. XXVIII.—*On the youngest Huronian Rocks south of Lake Superior and the age of the Copper-bearing Series;* by T. B. BROOKS.

IN the summer of 1874, Chas. E. Wright and myself, while exploring the country west and south of the Menominee River about ninety miles from its mouth, under the auspices of the Wisconsin Geological Survey, observed a large granitic area, the north edge of which was bounded by dark-colored hornblendic and micaceous schists of Huronian age, which I have since concluded are the equivalents of the youngest member of that series yet observed in the Marquette Iron Region.* The prevailing form was a medium to coarse-grained gray granite, with rectangular crystalline facets of feldspar.† In places it passed through gneissoid granite to a true gneiss, which was once hornblendic, the schistose structure of which always conformed with the underlying schists.

The lithological character of this wide granitic belt bore so much general resemblance to the Laurentian rocks, which are extensively developed on the waters of the Sturgeon River in Michigan, 10 to 20 miles to the northeast, that we were disposed at the time to believe that some phenomena of folding or faulting had brought rocks belonging to that system to the surface in an unexpected quarter. Professor Pumpelly and myself, several years previously had observed, farther to the north and west, similar granitic rocks crossing the Michigamme and Paint Rivers (branches of the Menominee), presenting similar puzzling relations with beds known to be Huronian. This formation is noticed in my Michigan Report, vol. i, p. 175, and the probability of its being Huronian, and younger as well as lithologically different from any rocks then known to be of that period, is pointed out.‡

* The staurolitic mica schist, Bed XIX of my scheme. See vol. i, pp. 83 and 130, Michigan Geological Report, 1873.

† A few small granite dykes were observed penetrating the hornblende schists along the granite border.

‡ It is not improbable that some of the granitic rocks S. W. of Michigamme Lake in the Marquette Region, may belong to the same horizon.

A careful consideration of all the facts to be observed in the Menominee Region confirms me in this hypothesis,* which is further supported, as it seems to me, by observations in the Penokie Iron Region (Bad River), Wisconsin.

Colonel Whittlesey's maps and sections, given in Owen's Report, 1852, represent a belt of granite, syenite, and hornblende rocks as dividing the Penokie series (Huronian) from the overlying Copper-bearing amygdaloidal traps and sandstones, which lie to the north and nearer the lake.

I observed these rocks at several points in 1871, and noted their general lithological resemblance to the Laurentian, as well as the almost insurmountable structural difficulties in assigning to them that age, and recorded in my notes the probability of their being Upper Huronian. Rowland Irving mentions these rocks† as being coarsely crystalline aggregates "chiefly of labradorite and orthoclase feldspar, hornblende, and some variety of pyroxene," with occasional evidences of bedding, which points toward their entire conformability with the underlying Huronian. He regards them as of the period of the Copper-bearing series, constituting its lowest and oldest portion.

Having been, so far as I know, but little studied, it is perhaps impossible at this time to determine their age: but what is known can here be briefly surveyed, and an inference drawn, which will not be without value in directing further investigations.

1. The general lithological similarity of this granitoid belt to the Laurentian, has been remarked. It has quite as much similarity, if not more, to several members of the Huronian; and is, I believe, not identical with any rock known to belong to the Copper series.

2. Its geographical extension is peculiar in this: it wedges out rapidly to the east from the vicinity of Penokie Gap, entirely disappearing at the Montreal River, which divides Michigan from Wisconsin. Professor Pumpelly and myself traced the boundary between the Copper and Huronian rocks 30 miles farther eastward beyond Lake Gogebic, without again observing it, which we should certainly have done if it had existed there; for we often found the two series very near together, although the actual contact was not seen.

* Dr. H. Credner regarded the entire Marquette series as the equivalents of the lowest member (a quartzyte) of the Menominee Huronian, a position not at all borne out, as it seems to me, by the facts. He seems to have based this geognostic reasoning largely on a rough section which I sketched for him (and which he has reproduced) of the Negaunee District, where the Upper Huronian, so well developed at Michigamme Lake, is wanting. His great overestimate of the thickness of the Menominee rocks has also led him astray. (See Zeitschrift der deutschen geologischen Gesellschaft, Band xxi, 1867, p. 553.) No attempt was made in my Michigan Report to correlate the Marquette and Menominee series, each being provisionally numbered independently.

† Am. Jour. Sci., vol. viii, 1874, p. 49.

3. Not only does this granitoid formation thin out and disappear in its eastward prolongation, but the same is true of the whole Huronian series, the belt of which becomes narrow as followed east, and finally disappears in the neighborhood of Gogebic, where the Laurentian is seen very near the Copper series.*

4. The fact that the granite mass does not cross either the Copper or Huronian series, or, so far as observed, give off dikes in either, renders it improbable that it came into its present position as an eruptive mass subsequent to the formation of both series of rocks.

5. The various ores of iron, which are so generally and abundantly diffused in the Lower and Middle Huronian, are entirely absent so far as observed from the upper three or four members as developed in the Marquette and Menominee regions, and also in the Penokie series if the following hypothesis is true; but they occur in all forms, although, it is believed, not abundantly, in the uppermost *exposed* member on Black River.† If we suppose this iron to have been mostly precipitated as a carbonate, then we might expect it would be more generally diffused through the rocks of certain epochs than those materials derived from the erosion of adjacent coasts.

There is evidently but one hypothesis which will reconcile these facts, which is: that the granitoid formation in question is of the Huronian period, and probably the youngest member; which series are here *non-conformably* overlaid by the Copper-bearing rocks. I conceive that this view is supported by the observations in the Menominee region above recorded, and suppose this Penokie granitoid formation may be the equivalent of granitic bed XX of the Huronian series as developed in that region. On this hypothesis, it is possible that the valley dividing the Penokie Range proper from the granitoid belt may be underlaid by a soft slate, the equivalent of the micaceous schist, bed XIX.

I would anticipate the objection which many will make to attaching much weight to lithological evidences in determining the age of formations 100 miles apart, by repeating that the staurolitic mica schist formation (XIX) maintains its mineralogical character for over one half this distance. I fail to understand why conditions favorable to the formation of extensive areas of particular rocks may not have existed occasionally in Archæan Time, since they were so prevalent in the following ages. This idea of equivalency is further supported by facts given in my "Revised Descriptive Catalogue of the Michigan State Suite of Huronian Rocks," in preparation.

* Pumpelly and Brooks, this Jour., vol. iii, 1872.

† The best point for observing the Huronian between Lake Gogebic and Montreal River.

The approximate conformability in strike and dip of the Huronian and Copper series, observed by Prof. Pumpelly and myself between the Montreal River and Lake Gogebic,* would, in this view, be only accidental and not prove identity of age, as we were at the time inclined to suppose, and with which view Mr. Irving agreed.

As supporting the view that these pre-Silurian systems † are of distinct periods, I would call attention to their well-known points of difference. The Huronian series of stratified greenstones, chloritic and related schists, clay slates, quartzytes, marbles, micaceous and hornblende schists, gneisses and granites, containing no copper or other metallic ores, except great conformable beds of magnetite, hematite, and limonite, differ as widely as may be from the compact and amygdaloidal melaphyres, friable sandstones, conglomerates with porphyry pebbles, which constitute the bulk of the Copper series, the whole more or less charged with native copper and silver; all of which points strongly toward a different origin for the two systems.

In their metamorphoses and movements subsequent to their deposition, there is a not less wide divergence noticeable. The friable sandstones of the Copper series, showing no greater metamorphism than the overlying Silurian for which they are often mistaken, has no counterpart in the highly crystalline schists and quartzytes of the Huronian, where we have only just enough of the arenaceous character left in some of them, to leave no doubt as to their fragmentary origin. But the difference in the amount, sharpness, and regularity of the folding and bending of the rocks of two systems into existing wave-forms, is if possible wider than their lithological variations. Contrast the magnificent regular sweeps of the Copper series, the main ranges of which preserve the same strike and direction of dip from Keweenaw Point westward for 150 miles, presenting for half the distance only the south upturned edge of the broad synclinal which embraces one fourth of the great lake in its basin;‡ with the older system, everywhere sharply folded into narrow troughs and irregular basins, trending in every direction, the upturned edges of whose enclosing rocks box the compass, winding and zig-zaging in outcrop like a sluggish river.§

* This Jour., vol. iii, June, 1872.

† I regard the non-conformability and difference in age of the Copper-bearing series and Lower Silurian rocks of Lake Superior, as established by the facts recorded in the papers of Prof. Pumpelly and myself and of Mr. Irving, in this Journal, already referred to. The hypothesis that the Copper rocks are the youngest Silurian formations of Lake Superior and were deposited during a period of elevation and depression which ceased at the beginning of the St. Mary's (Potsdam) epoch, I conceive is not supported by recently observed facts.

‡ See Irving's interesting remarks, this Jour., vol. viii, July, 1874.

§ Dr. J. P. Kimball, called attention to this structure in 1865, in this Journal.

If we extend our observations to the older and again non-conformable* Laurentian, we find the rocks still more plicated and metamorphosed, often even to the extent of entirely obliterating all evidences of stratification. If we suppose the forces which have produced the metamorphosis and the wave forms to have acted regularly and constantly from the beginning of Archæan time to the beginning of the Paleozoic, we may easily suppose the above results produced, viz.: the Laurentian most disturbed and changed, the Huronian next, and the Copper series least, the Silurian practically not at all.

A fact not without interest is the entire absence, so far as I know, of any patch even of rocks of the Copper period south of the great Keweenaw belt. If the two systems were conformable and of the same age, it is difficult to suppose it possible that erosion should have entirely denuded all the Huronian area which must have been covered by the Copper series of the rocks of that period. One would expect that somewhere a mass of these supposed younger Huronian beds would have been embraced in some one of the numerous sharp, deep synclinals, and have been found by those indefatigable mineral prospectors who have so thoroughly searched this region. On the hypothesis of non-conformability, it is much easier to conceive how it was possible for Silurian breakers coming from the south, slowly advanced by a subsidence from the same direction, to have done their work in completely uncovering the present Huronian area and leaving the great Copper range escarpment one of the most striking topographical features as well as the most difficult geological problems in the Northwest. It is easy to suppose for example, the horizontal Silurian rocks being entirely eroded from any Archæan terrains, but not of the Huronian rocks being entirely eroded from a Laurentian area, for the reason already given. Lastly, Logan states, Geology of Canada, 1863, p. 77, that "certain conglomerates of the Lower Copper-bearing rocks north of Lake Superior repose non-conformably on the upturned chloritic schists of the Huronian."

We are therefore justified, I think, in regarding the Copper-bearing rocks of Lake Superior as a distinct and independent series, marking a definite geological period which separates the Silurian from the Huronian ages. Should future observations confirm this view, it would be advisable to have some more convenient and geologically acceptable name for the series than that now in use. Since Keweenaw Peninsula forms one of the most striking geographical features in Lake Superior and is the locality where the Copper series are best exposed and were first studied, I suggest the name Keweenawian for this period.

* Pumpelly, Credner and myself have observed and recorded this in publications already referred to.

The difference in age of the Huronian and Laurentian having been proven, as already remarked,* by observed non-conformability, by the great rarity, in the younger series, of granite and greenstone dykes so numerous in the older, warrants us in reasserting the same kind and degree of unity and independence regarding the Huronian series.

The considerable amount of carbon distributed through the Huronian, indicating much organic life in that period, leads us to hope that those "imperfect fucoidal impressions" seen by Mr. Julien (Mich. Report, vol. ii, p. 5.) may not prove delusive, and that we shall yet be able to avail ourselves of paleontology in determining the age of this system.

The Laurentian rocks have been too little studied to justify an opinion as to whether they may be separated into two or more non-conformable systems, as has been attempted in Canada.

Art. XXIX.—*On a new Method of Measuring the Velocity of Electricity;*† by Joseph Lovering, of Cambridge, Mass.

Perhaps it is not too strong a statement to say that a question is half answered when it is properly asked. Now when it is asked, *What is the velocity of electricity*, there is no strict propriety in the question. For electricity has no *velocity*, in the common sense of the word *velocity*. There is no analogy between the transmission of an electrical disturbance and the propagation of light, or sound, or radiant heat, for example. The mathematical theory of the galvanic circuit, as stated by Ohm in 1827, and the more recent analysis on the same subject by Kirchhoff and Sir William Thomson, have appeared to prove that the time of transmission of an electrical disturbance is proportional to the total electro-statical capacity of the conductor, multiplied by its total resistance. As each of these factors increases with the length of the conductor, the time of transmission is proportional to the *square* of the length of the conductor. Therefore, it cannot be told with what velocity electricity will move until it is known through what distance it must travel. If it be asked, not what is the velocity of electricity, but what is its time of transmission, in any particular case, there would be more hope of a definite answer. The distinction just indicated will do much towards reconciling the contradictory results of experiment in regard to what is erroneously called the velocity of electricity; these experiments making the velocity appear to be sometimes as great as 288,000 miles a second, and sometimes no more than 800 miles a second. In the first case the experiment was made on a very short conductor, and in the second case on a conductor of great length.

* See my Michigan Report, vol. i, pp. 126, 156.

† From the Proceedings of the American Association for the Advancement of Science.

When experiment undertakes to deal with such amazing rates of transmission as those of light or electricity, one of two things is indispensable; it must possess the means, either of operating over enormous distances of space, or of measuring excessively small intervals of time. When the propagation of light is under consideration, there is a free choice between the two methods. If we choose the first, which may be called the direct method, astronomy will supply ample spaces, and no extraordinary nicety of measurement in the other element is demanded. But the practicability of the second method, even when the spaces traversed by the light do not exceed the limits of the physical laboratory, has been demonstrated by Fizeau, Foucault and Cornu.

If we turn now from the propagation of light to that of electricity, it is obvious that nothing less than the largest lines of telegraph wire furnish the conditions required by the first method. On the 28th of February, and again on the 7th of March, 1869, the late Professor Winlock, of the Harvard College Observatory, sent electrical signals from Cambridge to San Francisco, and thence by other lines to Canada, and back again to Cambridge, over a loop of wire measuring 7200 miles. This long journey was performed by electricity in about two-thirds of one second; and no small portion of this brief interval was lost in bringing into action the thirteen repeaters which were interpolated into the circuit. In the determination of longitude by telegraphic signals, the transmission time of the signals comes out as an incidental result. When the signals are sent eastward, the apparent difference of longitude exceeds the real difference of longitude by the transmission time. When the signals are sent westward, the apparent is less than the true longitude by the same quantity. The average of the two values is the true difference of longitude, and half the difference of the two values is the transmission time of electricity. For example, in the campaign conducted by officers of the United States Coast Survey, in 1869–70, for the determination of transatlantic longitudes, I obtained the following results. The total transmission time between Brest, France, and Duxbury, Mass., by the way of St. Pierre, was ·816 of one second. The total distance by cable is 3329 nautical miles; the distance from Brest to St. Pierre being 2580 nautical miles, and that from St. Pierre to Duxbury 749 nautical miles. When the differences of length, caliber and materials as between the two branches of the cable are all taken into account, I find that the transmission time between Brest and St. Pierre was ·639 of a second, and between St. Pierre and Duxbury ·177 of a second, so that the two branches were traversed, one at the rate of about 4000 nautical miles a second, the other at the rate of 4230 nautical miles a second.

Wheatstone's remarkable experiments on the velocity of friction electricity, first published in 1834, offer an example of the second method of measuring great velocities. In this case, the experiment was made upon a length of only one-quarter of a mile; and the exceedingly small fraction of time required by electricity

to traverse this short distance (amounting to only $\frac{1}{1152000}$ of one second) became distinctly measurable by the relative displacement which it produced in the images of two sparks, formed in a rapidly revolving mirror. Hence the hasty conclusion was adopted that the velocity of electricity was 288,000 miles per second. The immense discrepancy between this result and those afterwards reached by experiments on land and ocean lines of telegraph could not be overlooked, and an explanation was sought in the different tensions of friction and voltaic electricity. This explanation was unsatisfactory because direct experiments on telegraph wires appeared to indicate that the velocity of electricity was independent of the strength of the battery. The discrepancy itself vanishes, or changes its character, when attention is given to the law that the transmission time of electricity is proportional to the square of the distance. Wheatstone's experiment simply proved that electricity will go through one-quarter of a mile of wire at the rate of 288,000 miles per second, and that it would pass over only 268 miles of similar wire in one second. Now this is a much *smaller* velocity than is found by experiments on either land or ocean lines of telegraph; the reason being, probably, that in the inferences from Wheatstone's experiment no account has been taken of the intervals of air which separated the different branches of the conducting wire.

The theoretical law, already stated, viz.: that the transmission time increases with the square of the velocity, has been verified experimentally by Gaugain. He used two threads of cotton, each of which was 1·65 meters in length. When tried separately, the transmission time on each was eleven seconds. When they were placed end to end, so as to double the length, the time was forty-four seconds.

As Wheatstone's experiment on the velocity of electricity has never been repeated, and as direct experiments upon telegraph lines are not numerous and are not likely to be rapidly multipled, and have not been hitherto very harmonious in their results, some other indirect method of conducting the investigation may be found of scientific value. For this purpose, I have availed myself of Lissajous' method of compounding the rectangular vibrations of two tuning forks, and amplifying the resultant motion, by the twice reflected beam of light, which afterwards enters a telescope.

The tuning forks and telescope are permanently fixed to a base-board, so as to preserve their adjustment. Each tuning fork is provided with an electro-magnet, in order to maintain its vibration for a long time. The tuning forks, when vibrating independently, are nearly in unison, each making about 128 vibrations in one second. When the electro-magnets are brought into action, by a voltaic current circulating continuously through them and a standard tuning fork, furnished with an electro-magnet and a break-circuit attachment, the first two forks are forced into exact unison with the standard, and, therefore, with each other. Under these circumstances, the resultant orbit seen in the telescope is in-

variable. If the instrumental corrections for the two electro-magnets are equal, this orbit will be the first of the series for the unison; that is, an oblique straight line. If this is not the case, it will be convenient to make it so, by introducing resistances at the proper place in the circuit. Then, the apparatus is ready to be put to the work of measuring the velocity of electricity. An additional length of resistance coil is introduced, sufficient to change the orbit to some other in the series. The best one to select is the straight line which inclines in the opposite direction. The new orbit proves that one of the forks begins a vibration by half a period behind the other fork; which, in this particular case, is $\frac{1}{256}$ of one second. This fraction of a second is the transmission time for the passage of the current through the additional resistance coil. Unison forks of higher pitch would register smaller fractions of time. So would also forks, in which the ratios of vibration were less simple; but the orbits would be more complex and could not be observed with the same precision as the straight lines.

I have perfected the apparatus, just described, to such an extent as to feel assured of its adaptation to the purpose which has been specified. But I wish to make a larger number of observations, upon different lengths of resistance and under various combinations, before I give numerical results. I propose, hereafter, to subject in this way to experimental trial, the theoretical law that the transmission time increases with the square of the distance, and that the velocity is inversely as the distance. If this law holds good, the unit time and the unit velocity may be found for a unit distance, or a unit resistance, and then the time and the velocity can be computed for any other distance or resistance. This unit time and unit resistance must be accurately calculated from a combination of all the results of the various experiments. It is also desirable to ascertain the time and velocity for coiled and uncoiled, for naked and covered conductors; as also for air lines and ocean lines. It is to be observed that, in all cases, the time and velocity ascribed to the passages of the electricity apply to that amount of electricity which is required to work the receiving instrument.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Problems in Chemical Dynamics.*—In continuing his valuable researches in thermo-chemistry, Berthelot has developed some important facts in chemical dynamics. He finds that sodium butyrate when crystallized contains three molecules of water, all of which it loses in a dry vacuum or when heated to 110° C. The last half molecule of water is very persistent; so that by careful management, a definite hydrate of this composition

can be isolated. If now, these salts be dissolved in 120 parts of water at 6°, the anhydrous salt dried at 110° sets free 4·27 calories, the same salt dried in a vacuum 4·21 calories, the lower hydrate 3·66 calories, and the ter-hydrate 3·44 calories. Hence (1) the anhydrous salt is identical, however dried; and (2) heat is set free when a salt already abundantly hydrated, is dissolved in water. From the above numbers also, it appears that the union of the half molecule of water (liquid) with one molecule of the anhydrous salt sets free 0·58 calory; while the subsequent union of this with the two and a half other molecules of liquid water, sets free only 0·22 calory. If these values for liquid water be converted into those for water in the solid state by subtracting from them the heat of fusion of water, 0·715 for each half molecule, then the curious fact appears that the union of the first half molecule *absorbs* 0·135 calory, that of the subsequent two and a half 3·55 calories, while that of the three together is 3·49 calories; or in other words the union of solid water to solid sodium butyrate to form a crystallized hydrate, causes a considerable absorption of heat, contrary to the general fact. Consequently it is clear that the formation of hydrated sodium butyrate at a temperature at which water is liquid, i. e., above zero, must be attended with the evolution of heat, while the same hydrate produced with solid water, below zero, would cause an absorption of heat in its production. Berthelot calls attention to the change of sign in the heat-relations produced by combination at different temperatures as being a fact of the same order as that observed in allotropic elemental changes, such as for example, those of sulphur. The thermic relations then of allotropic changes of state are thus closely approximated to those of a chemical reaction properly so called; the stability of the bodies formed being intimately related to the changes of sign in the heat-relations attending their transformation.—*Ann. Chem. Phys.*, V, vi, 433, Dec., 1875. G. F. B.

2. *Action of Light on Silver Bromide, colored and uncolored.*—H. Vogel has given a *resumé* of the results of his recent experiments upon the chemical action of light upon silver bromide both pure and when mixed with some coloring matter. He finds: (1) that pure silver bromide shows by sufficiently long exposure to a strong light, a sensitiveness even to the ultra-red rays—having obtained plates showing not only the line A but a line beyond this, at a distance equal to that between A and B. Silver chloride is also sensitive as far as A and silver brom-iodide even beyond. (2) To the substances already mentioned, which increase the sensitiveness of silver bromide for the special rays which they absorb, may be added methyl-violet and cyanin, the latter increasing remarkably the sensitiveness for the orange. (3) In place of putting the coloring matter into the collodion as formerly, Vogel now prefers to flow the previously prepared plate with an alcoholic solution of the coloring matter which is then allowed to dry. (4) Experiments are necessary to determine the strength of these alcoholic solutions, since when they are too strong, the light is seri-

ously weakened before reaching the collodion. If, however, the prepared plate be exposed to the spectrum from the back side, this difficulty will be avoided. Moreover, in this way the action of imperfectly transparent coloring matters may be tested.—*Ber. Berl. Chem. Ges.*, viii, 1635, Jan., 1876. G. F. B.

3. *Corrosion of Platinum Stills by Sulphuric Acid.*—In 1862, SCHEURER-KESTNER communicated to Dr. Hofmann the results obtained by him in concentrating sulphuric acid in stills of platinum, which were published by the latter in his Report. The figures there given having been criticised as exaggerated, the author now publishes further facts upon this question. From 1851 to 1861, 4309 tons of sulphuric acid were concentrated to 66° B. in an alembic, the body of which weighed 40 kilograms. The entire loss of this part of the still was 12295 grams or 2·859 grams for each ton of acid. To destroy the nitrous products which were the cause of this large loss, ammonium sulphate was added in amount just sufficient for the purpose. In 1862, 1843 tons of acid were concentrated in the still, with a loss of 2490 grams; being 1·22 grams of platinum for each ton of acid, a marked decrease. From 1864 to 1875, 17516 tons of acid (of 1000 kilograms each) were concentrated to 66° in a still the body of which weighed 50 kilograms. The acid contained no nitrous compounds, and only sulphurous acid. The loss of the still was 16178 grams, or 0·925 grams to the ton of acid. To produce acid therefore of 66° B. containing 94 per cent H_2SO_4, there is a loss to the still per ton of acid of one gram when nitrous compounds are absent, and of 2½ to 3 grams when they are present. These numbers are much increased however, by carrying the concentration above 66°. In a still weighing 30 kilograms, 180 tons of acid were produced, containing 97–98 per cent real acid. The still lost 1092 grams platinum, or 6·07 grams per ton of acid. In producing 47 tons of acid of 99½ per cent, there was a loss of 8·80 grams platinum per ton of acid. An analysis of the acid itself showed 8·38 grams of platinum to the ton, in solution in it. To the figures here given for the loss of the body of the retort, about 13 per cent should be added for the other parts. It appears then that this loss of platinum in concentrating sulphuric acid is actual, and that it is a chemical not a mechanical one. The use of a platinum-iridium alloy for the stills prevents to a large extent this action, but the brittleness and consequent fragility of the alloy is a serious objection to it.—*Bull. Soc. Ch.*, II, xxiv, 501, Dec., 1875. G. F. B.

4. *Production of a Secondary Hexyl Alcohol.*—OECHSNER DE CONINCK has studied the products obtained by the hydrogenation of ethyl-butyryl, a mixed acetone discovered by M. Friedel among the products of the dry distillation of calcium butyrate. To obtain the ketone, two kilograms of this salt were distilled in portions of 150 grams, and gave 660 grams of distillate, which when fractionated yielded a little butyral, considerable methyl-butyral, 80 grams of a limpid highly refractive liquid of a strong

ethereal odor, boiling at 122°–124°, which analysis showed to be ethyl-butyryl, and a considerable quantity of butyrone. To hydrogenate this mixed ketone, a layer of water was placed in a flask, and on this the ketone was placed. On adding sodium in fragments, these sank through the upper layer, came in contact with the water, evolved hydrogen and rose through the ketone again, and so on. On fractioning, a limpid mobile highly refracting liquid passed over at 134°, which had an agreeable ethereal odor and a burning taste, and which afforded on analysis the formula $C_6H_{14}O$. Hence it is a hexyl alcohol, and since it is formed by the fixing of hydrogen on ethyl-butyryl ketone as isopropyl alcohol is from acetone, it is a secondary alcohol. The reaction is expressed as follows:—

$$\left\{\begin{array}{l} C_2H_5 \\ CO \\ C_3H_7 \end{array}\right. + H_2 = \left\{\begin{array}{l} C_2H_5 \\ CHOH \\ C_3H_7 \end{array}\right.$$

Isohexyl alcohol is soluble in ethyl alcohol and ether, scarcely in water. Its density at 20° is 0·81825, it etherifies readily with hydriodic acid, yielding an iodide boiling at 164°–166°, and an acetate boiling at 149°–151°. Beside this alcohol, an oily liquid was obtained in the distillation after treatment with sodium which boiled at 252°–255°, and had the composition $C_{12}H_{26}O_2$. Investigation showed it to be a pinacone produced by the union of two molecules of the ethyl-butyryl, with a fixation of an atom of hydrogen on each. Its formula is—

$$\begin{array}{ccc} H_5C_2 & & C_2H_5 \\ & | \quad | & \\ HOC & - & COH. \\ & | \quad | & \\ H_7C_3 & & C_3H_7 \end{array}$$

Treated with sulphuric acid, and fractionated, it yielded on analysis numbers indicating a mixture of a pinacolin and a hydrocarbon, but the quantity was too small to effect their separation.—*Bull. Soc. Ch.*, II, xxv, 7, Jan., 1876. G. F. B.

5. *On Rosolic Acid.*—Graebe and Caro have made a more complete investigation of the acid which Wanklyn and Caro obtained from rosaniline by converting it into the diazo-compound and then decomposing it by water, with a view to throwing some light upon the constitution of rosaniline itself. This acid, which had been called rosolic acid, was supposed to be identical with a substance obtained by the action of oxalic acid on phenol, by Kolbe and Schmitt. But this latter product was shown by Dale and Schorlemmer to be a mixture, and they isolated from it a coloring matter which they termed aurin, and Fresenius separated a second substance which he termed corallin. Graebe and Caro propose therefore to retain the name rosolic acid for the rosaniline derivative. The rosolic acid was prepared by the method given above and gave on analysis the formula $C_{20}H_{16}O_3$. It forms ruby-red crystals with a green reflection, is soluble in hot alcohol, glacial acetic acid and ether, insoluble in benzine and

carbon disulphide, slightly soluble in water. It acts like a weak acid, the ammonia salt crystallizing in needles. By reducing agents it is converted into hydro-rosolic acid, and by KCy into hydro-cyan-rosolic acid. Acid alkali sulphites dissolve it to a colorless solution. Oxidizing agents convert it into a minium-red substance. By heating with acetic oxide no acetyl-derivatives are produced. Warmed in alkaline solution with zinc dust, leuco-rosolic acid is obtained in colorless silky crystals. This yields a triacetyl derivative. Triacetyl-hydrocyan-rosolic acid, tetrabrom-rosolic acid, tetrabromleucorosolic acid and hydrocyantetrabrom-rosolic acid are described, and the analogy of this body to the phthaleins in this respect is noted.—*Liebig's Ann.*, clxxix, 184, Nov., 1875. G. F. B.

6. *On the Synthesis of Betaine.*—Betaine (or oxyneurine as it is also called) is known to be a tri-methylated glycocoll. GRIESS has succeeded in effecting a new synthesis of it by acting on an alkaline solution of glycocoll with methyl iodide. The glycocoll (one atom) is dissolved in an excess of concentrated potassium hydrate solution, the methyl iodide (three atoms or more) is added, and as much methyl alcohol as is needed to make a homogeneous mixture. Soon a reaction sets in, the mixture becomes acid and alkali must be added. The liquid is neutralized with hydriodic acid, the methyl alcohol distilled off, the residue diluted and a solution of iodine in hydriodic acid added. On standing, blackish-brown brilliant needles of betaine periodide separate. These suspended in water and treated with H_2S afford pure betaine hydriodate, from which the other salts and the free base can be easily prepared.—*Ber. Berl. Chem. Ges.*, viii, 1406, Nov., 1875. G. F. B.

7. *A New Acid isomeric with Alizarin.*—SCHUNK and ROEMER have discovered in the commercial alizarin made by Perkin in London an acid of the formula $C_{14}H_8O_4$, isomeric not only with alizarin itself but also with anthraflavic acid. From alcohol it crystallizes in long brownish-yellow needles. It is soluble in baryta water with a dark red color, but possesses no coloring properties. The authors are engaged in studying it more thoroughly.—*Ber. Berl. Chem. Ges.*, viii, 1628, Jan., 1876. G. F. B.

8. *On the Constitution of Acids and Salts.*—BERTHELOT has given a resumé of his results obtained by a thermo-chemical investigation of the composition of acids and salts when in solution, which affords a ready method for their classification. According to his experiments, the relative energy of acids and bases may be measured by the inequality of decomposition of their salts by water, added in gradually increasing amount; this decomposition being indicated by the amount of heat absorbed or evolved. Thus in the first class are placed strong acids and bases. These, when dissolved separately in water and mixed in equal equivalents, form stable neutral salts, and set free a quantity of heat nearly constant for all the bodies of this class, and which does not vary when more water is added, nor by the addition of more of

the same or of another base. To this class belong the chlorides, nitrates, and normal sulphates of the fixed alkalies. In the second class of acids and bases, Berthelot places those which are decomposed by water progressively, the decomposition increasing with the amount of water added. Sometimes this increase is continuous either indefinitely, or possessing a definite limit. To this class belong borates, carbonates, cyanides, sulphides, alkali phenates, acetates, butyrates and valerianates. Sometimes the decomposition takes placed in its entirety by the first portion of water added; so that the thermometer shows an absorption of heat nearly equal to that which is evolved in the original formation of the salt. Such are the salts formed by the alkalies with alcohol, glycerin, mannite, etc. Of course the decomposition by water is the more marked when the base is also feeble, like the oxides of the heavy metals. In this case, the decomposition is apparent even with acids of the first class. Even ammonium salts with strong acids are thus decomposed, though to a less degree than when the acid is weak. The author draws the conclusion that in solution, strong acids always unite with strong bases, leaving the feebler members to each other. To account for the stability of the alkali-salts of strong acids, he supposes that the formation of definite hydrates by the union of water with the acid and the base, taken separately, under the conditions of the experiment, sets free a total amount of heat which is less than that evolved in the formation of the normal salt itself. So, reciprocally, if the alkali-salts of feeble acids are decomposed by water, the reason is to be found in the excess of the thermic effects due to the formation of hydrates over those which result from the formation of the normal salt. Several of the many important considerations which flow from this hypothesis are given at length in the paper.—*C. R.*, lxxxi, 844, Nov., 1875. G. F. B.

9. *Division of an Acid among several Bases.*—M. Berthelot has endeavored to solve the question whether, if an acid is present with several bases, it will unite with one, or be divided among them. Berthollet believed that each base would take an amount of the acid determined by its capacity for saturation and its quantity; for equal weights that each body would take an amount inversely as its equivalent: or, if the bases were employed in amounts proportional to their atomic weights, each would take half the acid. Gay Lussac believed that a complete mixture took place, and that the salts were formed only when separated by their insolubility, crystallization or volatility. To test these views, two bases were selected which disengaged an unequal amount of heat in uniting with the same acid. Thus mixtures of equivalent weights of chloride of ammonium and caustic soda were mixed. The difference in this case of the two bases would equal 1·12 units of heat. Were the theory of Berthollet correct, half of the acid should go to the soda setting free ·56 units of heat. Other divisions of the acid might set free any quantity from 0 to 1·12. According to Gay Lussac there should be no

generation of heat, or at least the amount should be uncertain. Finally, if all the acid passed over to the soda, the amount of heat set free should be 1·12. The amount actually observed equalled 1·07, which as the probable error is ±·04, evidently sensibly equals 1·12. The very small difference of ·05 is also explained by the purely physical action exercised by ammonia on a solution of chloride of sodium. In fact a mixture of the same quantities of ammonia water and chloride of sodium absorbs ·05 units of heat. Similar effects are also obtained by replacing the chloride by the nitrate or sulphate, or by using potash instead of soda. Not only can ammonia be replaced by soluble bases such as potash or soda, but even by those which are insoluble, such as lime. According to Berthollet there should be a division at first, then a precipitation of the lime, and so on until it was wholly separated. But this effect is not produced, the lime is not precipitated but dissolved in the chloride of ammonium. To determine the real nature of the reaction a certain amount of lime was precipitated from the chloride by soda; 1·18 units of heat were thus absorbed. It was then dissolved by chloride of ammonia when 2·24 units of heat were disengaged. But in the latter operation the solution of the hydrate of lime by the ammonia should give out 1·10 units of heat; and the redissolving of the lime should give out 1·10, or in all 2·20, which agrees closely with 2·24, the observed amount. Again, the total heat set free, $-1·18+2·24 = 1·06$ is very nearly equal to 1·07, the amount set free in the previous experiment by the direct action of the soda on the chloride of ammonia. These facts and measures prove that the double salts and the change of the solvent are not the cause of the phenomena; while they are completely explained by the complete substitution of the lime, a nearly insoluble base, by the ammonia, a soluble base. We see therefore that this substitution may take place contrary to the laws of Berthollet.—*Ann. Chim. et Phys.*, vi, 662. E. C. P.

10. *A new Pyrheliometer.*—M. A. Crova has measured the calorific intensity of the solar radiation and its absorption by the atmosphere of the earth. With the pyrheliometer of Pouillet it appeared that the indications varied with the method of preparing the surface. If the silvered chamber containing the water is simply covered with one or more coatings of lampblack, a portion of the heat after passing through the coating is reflected by the metal and thence passes out through the lampblack which is diathermanous. The absorption is rendered more complete by employing an absorbing layer which is wholly metallic. A rough layer of copper is deposited galvanically on the box and on this a layer of platinum black. A large thermometer having a bulb 40 mm. in diameter and a tube 300 mm. long replaces the ordinary silvered box. The bulb is covered with silver, copper, platinum, and finally with a thin coating of lampblack. The tube ends with a second bulb containing a little mercury, which may be introduced as an index into the tube. This thermometer is

introduced into a hollow brass sphere polished without and blackened within, and having an aperture 30 mm. in diameter through which the sun's rays penetrate. The observation of the heating after numerous corrections gives with great delicacy the relative heat of the sun at different times.—*Comptes Rendus*, lxxxi, 1205.
E. C. P.

11. *Thermal Equivalent of Magnetism.*—M. A. CAZIN has published in full a series of experiments on the relations of heat and magnetism. In the first portion of the memoir three methods are described of measuring the relative values of the heat created by the disappearance of magnetism, in the core of an electro-magnet. The second section demonstrates several laws of the magnetic heat developed, and shows that this heat is really due to the disappearance of the magnetism. But in the induction of the core on the coil, and of the coil on itself, causes of heat are found which should be allowed for. The fundamental law deduced from these experiments is, that the disappearance of magnetism in the core of a bar electro-magnet having two poles is accompanied by the creation of a quantity of heat Q proportional to the polar interval l, and to the square of the quantity of temporary magnetism m which the core acquires when the circuit is closed. The product m^2l is a magnitude of the same kind as the quantity of heat Q and may be called the magnetic energy. The ratio $\frac{m^2l}{Q}$ will be the mechanical equivalent of heat. In the third section the value of Q is determined in units of heat while the effects of induction are inconsiderable. The first series gave as a mean of five experiments while the spark was broken in all 110600000, as the magnetic equivalent. A second more reliable series with the spark broken in ether gave 106000000. Both are a little too great because the induced current on breaking the circuit is not zero. Hence, probably the true value does not differ materially from 100000000.—*Ann. Chim. et Phys.*, vi, 493–554. E. C. P.

12. *Leyden Jar Regulator.*—Professor McLEOD at a recent meeting of the Physical Society showed an arrangement for ensuring that the charge given to a Leyden jar shall not exceed any fixed limit. Through a cork in the upper end of a bell-glass passes a brass rod, insulated through its entire length by a glass tube, through which it passes freely. To the upper end is attached a brass knob, and the lower end is pointed and provided with a screw thread, so that it can be set at any distance within, or through, a hollow brass ball, perforated below and rigidly fixed to the glass tube. Within the bell-glass is a loose cage of perforated sheet zinc and a vessel containing strong sulphuric acid. The whole stands on a metallic plate to secure a good earth connection. The action is as follows: if the rod be screwed down so that the point projects through the hollow ball, the upper knob and the lower metallic plate being connected with the two poles of a Holtz machine, only short sparks can be obtained, because a large amount of electricity escapes at the point; but if the rod

be raised so that it barely enters the hollow ball at the top, no escape takes place from it, and the machine will give its full length of spark. By varying the position between these two extreme limits, any required length of spark or amount of charge for an interposed Leyden jar can be obtained.—*Nature*, xiii, 140.

E. C. P.

13. *Report to the Philosophical Society of Glasgow on the Production of Nitric acid from the free Nitrogen of the air.* Part I. By E. M. DIXON. 18 pp. 8vo. Glasgow, 1875.—The author first discusses the researches connected with ozone made by Schönbein, Marignac, De La Rive, Baumert, Prof. Andrews of Belfast, and others, and states, as the accepted conclusion, that ozone is the only allotropic form of oxygen, in other words that antozone has no existence. The report then considers the production of nitric acid through the agency of ozone; four alleged methods of which are mentioned, viz.: (1) by contact of nitrogen or the atmosphere with bodies undergoing oxidation; (2) during electrical discharges in the air; (3) the combining of ozone with nitrogen in the presence of water; (4) through the evaporation and condensation of water in the air. The consideration of nitrification by the *first* method is pronounced to be as yet doubtful, but the consideration of it is deferred to the second part of the report. With regard to the *second* and *third* methods, it states that there is clear proof of the fact that the electric spark is capable of effecting the combination of oxygen and nitrogen in a dry mixture of these gases; but that there is little or no doubt that nitrification does not occur in nature from the action of ozone upon the nitrogen of the air; and that the production of peroxide of hydrogen in nature, as shown by Engler, Nasse, Carius, Schöne, must be ascribed to some other cause than the action of ozone upon either aqueous vapor alone, or upon it and nitrogen together.

Upon the *fourth* method, the report remarks as follows: "In 1862 Schönbein announced the fact that, if water is partially evaporated in the air, the residue contains nitrite of ammonia, and that the same salt is to be found in the water formed by the condensation of vapor in air. Of these facts there is no doubt. Schönbein, however, without ascertaining whether the salt in question did not exist ready formed in the air employed in his experiments, rushed to the conclusion that it must have been formed during these experiments, by the combination of free nitrogen with water. Obvious as the precaution indicated now seems to be, it must also be said that it does not appear to have occurred at the same time to any one else; and some, while accepting Schönbein's explanation of the production of nitrite of ammonia from free nitrogen and water, even thought to contest his claim to all the merit of having discovered so remarkable a property in free nitrogen. The following quotation from a recently published volume, by Dr. T. Sterry Hunt, entitled Chemical and Geological Essays, will show that he still claims a considerable amount of credit for having predicted, on theoretical

grounds, the possibility of producing nitrite of ammonia from free nitrogen and water, and for having framed thereupon a theory of nitrification.

"'On September 15, 1862, I read before the French Academy of Sciences a note on The Nature of Nitrogen, and the Theory of Nitrification, published in the Comptes Rendus of that date, and translated in the Philosophical Magazine for January, 1863, in which I repeated the points above given, and then proceeded to consider the results announced by Schönbein in 1862. I said, "The formation of nitrite of ammonia by the combination of nitryl NN with H_4O_2 must necessarily be limited to very minute quantities by the instability of this ammoniacal salt which, as is well known, decomposes readily into nitrogen and water. In order, therefore, to produce any considerable quantity of a nitrite by this reaction, there is required the presence of active oxygen, or of a fixed base to separate the ammonia. The recent experiments of Schönbein have furnished new evidences of the direct formation of a nitrite at the expense of the nitrogen of the atmosphere. According to him, when sheets of paper moistened with a feeble solution of an alkali, or an alkaline carbonate, are exposed to the air, especially in the presence of a watery vapor, and at a temperature of 50° or 60° C., the alkaline base soon fixes a sufficient quantity of nitrous acid to give the characteristic reactions. Appreciable traces of nitrite are, according to Schönbein, obtained in this way, even without the intervention of an alkali. He, moreover, found that distilled water, mixed with a little potash or sulphuric acid, and evaporated slowly at a temperature of about 50° C. in the open air, fixes in one case a small portion of ammonia, and in the other a little nitrous acid. Traces of a nitrite are also formed in pure water under similar conditions. Schönbein explains all these results by the combination of nitrogen with the elements of the water, producing at the same time ammonia and nitrous acid. As he has well remarked, this reaction serves to explain the absorption of nitrogen by vegetation, and through the oxidation of nitrite, the formation of nitrates in nature. By these elegant experiments he has confirmed, in a remarkable manner, my theory of nitrification, and of the double nature of free nitrogen. It is, however, evident that since the publication of my note of March, 1861, above referred to, we cannot say with Schönbein that the generation of nitrite of ammonia from nitrogen and water is 'a most wonderful and wholly unexpected thing.'"

"It is, however, unfortunate for Dr. Hunt's theoretical anticipations that no sooner did experimentalists begin to purify the air that they used in repeating Schönbein's experiments, than the production of nitrite of ammonia suddenly stopped. The experiments of Bohlig and, more recently, of Carius, show that neither during the evaporation of water in air, nor during the condensation of its vapor, does a trace of nitrite of ammonia manifest itself. The experiments of Carius are especially decisive on the point, as they were both numerous and most carefully performed. The

verdict here, then, is very clearly adverse to the statements that have been made regarding the evaporation of water and the condensation of aqueous vapor as sources of nitric acid."

14. *On the Electrical Conductivity of Stretched Silver Wires;* by J. G. MacGregor, M.A., B.Sc.—A paper on the above subject, communicated by Prof. Tait to the Royal Society of Edinburgh on the 3d of January, contained a description of a series of experiments, conducted by the author to find the effect of stretching on the conductivity of silver wires. The wires were stretched by weights. The measurements of resistance were made by means of a Wheatstone's bridge, the wire under examination being joined up as one of its arms. The dimensions of the wires before and after stretching, were determined by means of cathetometer observations and specific gravity determinations. The increase in length and decrease in thickness of the wires, caused by stretching, must of course be attended by a corresponding increase in their resistance. The question to be determined was whether there was not also a change produced in their resistance by the change produced by stretching in their molecular state. To get this effect, if it should be present, at its maximum the wires were heated to just below the melting point before the weights were hung on. The results were such as to warrant the statement that if any such change is produced it must be very slight, the difference between the resistances before and after stretching being (when that due to change of dimensions had been allowed for) so small as to be within the limits of observational error. No former determinations of this kind have been made for silver wires. For copper, iron and steel, Mousson has found that the change in resistance is not completely accounted for by the change in dimensions. In another respect also silver appears to differ from copper wires. Meik and Murray have found that the total increase in the resistance of copper wires, due to stretching, is directly proportional to the weights by which they are stretched. Some of the experiments of this paper show that this is not the case for silver wires.

15. *The Nature of Light, with a general account of Physical Optics;* by Dr. Eugene Lammel, Professor of Physics in the University of Erlangen. With 188 illustrations and a plate of spectra in chromolithography. No. xviii of the International Scientific Series.—This is a very excellent popular treatise, intended to afford an answer to the question "What is the Nature of Light?" A mathematical treatment of the subject is avoided in the text, but simple and concise analytical discussions of the more important topics are given in appendices to the different chapters. It is illustrated with numerous wood-cuts, many of which are novel and ingeniously devised, but most of them would have been more effective had they been engraved in a style worthy of the book. The work is an admirably clear and well arranged exposition of its subject, and is, in the main, well translated.

16. *Manual of Introductory Chemical Practice, for the use of Students;* by George C. Caldwell, S.B., Ph.D., Professor of Agricultural and Analytical Chemistry, and Abram A. Breneman, S.B., Assistant Professor of Applied Chemistry in Cornell University, Ithaca, N. Y. Published by the authors. 124 pp. 12mo. 1875.—This manual is an experiment on the part of the authors in a novel mode of chemical instruction, devised by them, with a view to cultivate on the part of the student habits of careful observation, attention to and appreciation of phenomena, and the deduction of legitimate results. In short it seeks to make the student his own teacher by simple synthetic or analytic experiments, and to lead him on by easy steps to an understanding of principles and of chemical philosophy—in a way unattainable from text-books alone. The student is required to give his results and conclusions in writing, an excellent way to secure accuracy and conciseness of statement. He is presumed to be in attendance on a course of experimental lectures, and to be reciting at the same time from a text-book. The work bears marks of careful preparation.

17. *Note on the Electrical Conductivity of Saline Solutions;* by J. G. MacGregor, M.A., B.Sc., Communicated to the Royal Society of Edinburgh, May 17, 1875; by Professor Tait (Proc. Roy. Soc. Edinb., 1875, 545.)—This note is a reply to criticisms by Professor Beetz published in the Sitzungsberichte of the Berlin Academy (and in Poggendorff's Annalen) on a paper of Mr. MacGregor's published in the Transactions of the Edinburgh Royal Society, xxvii, pp. 51–70. Mr. MacGregor shows that the criticisms are based in part on a misunderstanding of his paper and of his method of experimenting.

II. Geology and Mineralogy.

1. *Supposed Agency of Ice-Floes in the Champlain Period;* by Professor A. Winchell, Syracuse, N. Y.—I have lately discovered some new instances of huge limestone masses, anomalously detached from the formation to which they belong; and have embraced references to localities, in a paper read before the American Association at Detroit. These are masses of Carboniferous limestone from 10 to 60 feet in length and often of unknown thickness, floating in the sands of Oceana county, apparently 100 or 200 feet above the bed rock. Some of these, I feel constrained to believe, must be genuine exposures of the formation, in place; but others, by being worked out, or by their downhill dip, far exceeding, and disagreeing with, the normal dip of the formation, are demonstrably dissevered and displaced portions of it. For example, one region of exposures of this class in the town of Claybanks, is within half a mile of the shore of Lake Michigan, where we have a bluff 250 feet in height, and attaining, a few rods back, an elevation of 275 feet, serving as a station of the U. S. Lake Survey. The vicinity, for miles around, is elevated 250 to 300 feet above the lake.

But the section of materials exposed in the bluff upon the lake shore is wholly Post-tertiary. It consists of intimately mingled sand and clay, confusedly stratified above, horizontally stratified lower down, and followed downward by an increase of argillaceous material and pebbles, interrupted by a bed of bowlders, beneath which for 10 feet is a mass of bowlder clay seen above a lake-border talus of ten feet. According to the prevailing constitution of the drift of the Peninsula, there should lie, still lower, a thick bed of fine, horizontally-stratified clay, with few pebbles, resting on a bottom-sheet of pebbles and bowlders. The drift here is presumably not less than 300 feet thick. Now it is possible that, 2,500 feet back from this bluff, the bed-rock should appear at the surface: but my experience in Michigan strongly inclines me to believe that such is not the fact; and that hence, the numerous outcrops near the lake are mere detached masses.

We have, then, in Michigan, in regions widely separated, the well-established phenomenon of extensive tabular masses of limestone floating in the midst of semi-stratified sands, generally believed to have been moved and deposited by an aqueous action, which, obviously, could not have transported at the same time these enormous tables of rock. We have, in addition, in some parts of the State, the evidence that this action was sometimes exerted in a northerly direction. Geological theory must attempt to account for these facts.

The generally accepted doctrine of continental glaciation, recognizes a time when the broad glacier underwent a rapid dissolution. The volume of water arising is believed to have been sufficient to produce a long-continued, torrential flood, which moved and assorted whatever detritus existed in its path. Disregarding the detrital material, which must have originated from atmospheric, pluvial and fluvial action over the preglacial surface, a vast volume of detritus must have been originated during the prevalence of the glacier, and chiefly through its action. Most of this must have rested at or near the bottom of the glacier; but probably no small portion had become incorporated with the ice, or intruded into its fissures, or deposited upon its back. The first glacial film embraced the original projections of the ancient surface, which, with the movement of the glacier, must have been displaced to become ultimately a part of the glacier debris. These and the materials derived from sub-glacial detrition must have found their way, to some extent, into the *bottom crevasses* caused by any diminution in the steepness of the slope down which the glacier moved, and still more when, as was often the case, the change of slope became, in reality a northward declivity. These ordinary conditions of the continental glacier—but feebly represented in the steeper slopes and narrowed limits of modern glaciers—must have resulted frequently in extensive disruptions of the ice, faintly typified in the pyramids and seracs of the Alpine ice-streams. Such upheavals of the lower beds—still more, occasional complete overturnings of portions of the glacier, must have brought considerable earthy detritus to

the very surface of the glacier. In the process of ages, as the ice may be supposed to have gradually diminished, through evaporation, if not through thawing, the superficial earthy material, which never evaporated, must have accumulated to a large extent. However we account for this fact, every one knows that human bodies or other objects, accidentally lost in the glaciers of Mont Blanc, reappear at the surface after a series of years, at points some thousands of feet below.

I infer, therefore, that the material moved by the diluvial waters may have been afforded by some of the interior portions and even the surface of the glacier, as well as by the subjacent rock-rubbish. I will only add that some portions of the material in and upon the ice may have been let down *in situ* by the slow disappearance of the glacier, without having been subjected to the assorting action of the glacial torrents.*

This process is impressively illustrated along the borders of the Mer de Glace and other Alpine glaciers; and more instructively still in the buried glacier stumps found in the gulches of the Sierra Nevada, and elsewhere in the Pacific States.

I know of no certain evidences, in Michigan, of a Champlain depression of such extent as to bring the surface of any portion of the State below the sea-level. In a district so nearly horizontal, however, there must have been a period, before the erosions of the modern drainage courses had begun, during which the drainage was exceedingly obstructed and slow. The supply of water from the dissolving glacier was greater than could be discharged through the forming outlets; and the extensive areas must have lain submerged until the deepening of the outlets permitted their drainage. But this period was, by hypothesis, that when a geologic winter was merging into a geologic spring. There was not yet a summer climate; and the annual winter must have congealed the surfaces of the surrounding lakes, and arrested the superglacial torrents, if it did not materially diminish the flow of the subglacial ones.

I think the steps of this reasoning safe and sound. But we have here an overlooked condition of glacial agency in the natural order of sequence, which, it seems to me, is adequate to explain the transpositions of rock-masses to which I have referred. There were regions in these lakes where rocky formations rose nearly to the surface, or projected to a slight extent above it. On the freezing of the watery surface, these would be firmly embraced in the ice. Meantime, as the supply of water is diminishing through the advance of the annual winter, the lake subsides, and the frost takes hold of the exposed rock at a greater depth. But the annual spring and summer return. The supply of water increases, the surface of the lake rises and the floating field of ice lifts sheets of previously half-disjointed limestone, and floats them in the direction whither the current sets or the wind blows. They may be dropped some

* This idea was first impressed upon my attention by my brother, N. H. Winchell, who has studied the Drift with much assiduity. See his papers in Proc. Amer. Assoc., Dubuque Meeting, 1872, and in the "Popular Science Monthly" for June and July, 1872.

miles northward from their native bed, and may lodge upon an accumulation of sand moved by aqueous agencies quite inadequate to move cubic yards of solid rock. I think that ice floes are capable of such work; and I believe it is not essentially different from work in progress in the tracks of Arctic currents in modern times.

The same agency would have picked up and transported the rounded northern bowlders, which we find scattered, also, to some extent, through the same sands.

It could not be expected that the existing configuration of the surface of the State should preserve the features which determined the existence and boundaries of such local lakes as I have supposed; but, after all, are not our existing interior lakelets examples of the same, perpetuated by the delayed erosions of outlets? If it be asserted that neither the less nor the greater lakes are engaged in transportation of limestone masses, in our times, it will be a sufficient rejoinder to remind the reader that the supply of movable masses of limestone must ultimately have become exhausted. Still, it is not a fact that work of this kind has entirely ceased, as any one familiar with the flotsam thrown upon a lake beach will be led to admit.

Nor has time obliterated all traces of that topographical configuration, which in Southern Michigan may have determined an ice-float toward the north. Between Saginaw Bay and the mouth of the Grand River is a broad depression, the highest part of which rises but 72 feet above Lake Michigan. The southern tier of counties in the State presents an elevation of 300 to 600 feet above Lake Michigan. The Corniferous limestone barrier, passing through Monroe and Lenawee counties, still maintains an elevation of 100 to 150 feet above the same lake. Have we not here some vestiges of that ancient conformation of the surface which resulted in a northward drainage into the great channel once intersecting the State, and the northward transposition of ice-born sheets of limestone and sandstone, wrenched from the elevated barriers in Hillsdale, Lenawee and Monroe counties, and the contiguous portions of Ohio and Indiana?

2. *On the outlet of the Great Salt Lake;* by Professor G. K. Gilbert. (Letter to J. D. Dana, dated Washington, Feb. 4, 1876.)—I had not seen Mr. Packard's paper, when my attention was called to it by your letter of the 29th ult. Since he had "not observed personally any facts bearing on the subject," but merely advanced the ideas of others, it is not surprising that everything which is novel in his paper is erroneous.

When the water of Great Salt Lake was at its maximum altitude it carved and molded a beach, which yet remains—a conspicuous monument to its former greatness. Within the circle of this beach-line are included also Utah and Sevier lakes. The level of the ancient beach is 970 feet higher than Great Salt Lake, about 700 feet higher than Utah lake, and about 550 feet higher than Sevier Lake. From the upper beach the water slowly subsided by desiccation, recording its lingerings in a series of fainter

shore-lines. When it had fallen to the level of the divide between the Sevier and Salt Lake basins, it was separated into two unequal portions. In one of these the evaporation exceeded the inflow from rivers, and the subsidence continued; in the other the inflow exceeded the evaporation and the surplus was discharged over the divide into the former portion, just as the surplus of Utah Lake is now discharged into Great Salt Lake. In the course of time, as the climate became drier, this overflow ceased; but not until it had carved a channel of some magnitude. The channel is crossed by the old overland stage road, and is known as "the Old River Bed." It is doubtless this ancient water-way which has been described to Mr. Packard. I am not aware that it has ever been determined whether the channel slopes toward Sevier, or toward Great Salt Lake; but a consideration of the forms and dimensions of the two basins, and of the present relative salinity of the two lakes, leads to the belief that it was the Sevier Basin which overflowed into the other. The summit of the divide cannot be far above the present level of Sevier Lake.

In the early part of the field-season of 1872, I crossed the Salt Lake and Sevier deserts as a geologist of the Wheeler Expedition, and gave especial attention to the beaches and other phenomena of the ancient lake. Later in the season my associate, Mr. Howell, carried the observations farther south. Our examinations were sufficiently thorough to enable us to draw a map of the southern half of the old lake, but we found no evidence of an outlet in that direction, although we made diligent search. According to the conjecture of Professor Bradley, and the unpublished observation of Professor Marsh, the overflow was northward, and the Columbia River carried the water to the ocean. There assuredly was an overflow.

In the progress report of Lieut. Wheeler's Surveys for 1872, I have expressed the opinion that the humid climate which was marked by this inundation of Utah, was preceded by one as arid as the present; and that the humidity was a phenomenon of the Glacial Epoch. A fuller statement and discussion of the facts will appear in the geological volume (now in press) of the reports of the Wheeler Surveys; and the accompanying atlas will contain a map of the ancient lake.

3. *Second Report of Progress of the Mineralogical, Geological and Physical Survey of the State of Georgia, for* 1875; by George Little, State Geologist. 8vo, 16 pp.—This brief report shows a large amount of work done during the past year. The several parties have traversed, in all, over 6,000 miles of road, making careful examinations and large collections along their routes. They have visited 105 out of the 137 counties in the State, and a list is given of the minerals, metals and building-stones, of economical value, which have been found in 76 of these counties.

Under the head of Geology, Dr. Little says: "In the Northwestern portion of the State, the coal-formation has been found, by Mr. McCutchen, to be somewhat more extensive than observed

hitherto. There has also been some addition to our knowledge of the fossiliferous iron ore beds.

"The metamorphic rocks, on the western border of the Cohutta mountains, have been found to contain lead, copper and silver; while barite has been found at the base in Murray county, and large beds of the same near Stegall's station, in Bartow county. The relation of the metamorphic rocks in these mountains, as well as that in the Blue Ridge and across the Chattahoochee ridge, along the Tugaloo and Savannah rivers, to the corresponding adjacent parts of Tennessee, North Carolina and South Carolina, have been studied, and a regular succession of Potsdam, Quebec and Cincinnati rocks found, in alternating bands, while the whole of this metamorphic region appears to be of Silurian age.

"Prof. Bradley reports 'the extension of the gold-belt over large areas not previously recognized as gold-bearing; the determination of the age, equivalency and position of nearly every important stratum in the Blue Ridge of Georgia, including the copper ores of Fannin and Gilmer, as well as those of Lumpkin and Towns, and the corundum belts of Union, Towns and Rabun, (with the probable position of the equivalents of these latter in Habersham, White, Lumpkin and Dawson,) and the determination of numerous levels which affect both the working of large areas of the gold-field and the location of projected railroads. The points of greatest scientific interest are the identification of the serpentines, chrysolites, chlorites and steatites of the corundum belts, with the magnesian limestones of the Quebec group, (the Knox dolomyte of Safford,) and that the underlying schists of the gold-belt with the Knox shale of the lower part of the Quebec.'

"Prof. Loughridge has found in the Southern portion of the State, that the Cretaceous rocks extend from Columbus nearly to Ft. Gaines, affording valuable beds of marl, and that the Tertiary rocks continue, from a line drawn from Ft. Gaines via Macon to Augusta, over the whole of the Southern counties, abounding in deposits of marl and limestone, while the more recent formations, of Okefenokee and smaller swamps, afford an unlimited supply of marsh muck, which is already being utilized to the great advantage of crops.

"We are now prepared, after this preliminary survey, to enter upon the detailed, systematic and acurate survey of each county in the several divisions of the State; and it is proposed, during the next season, to begin this work at three points on the western border of the State—one party beginning with Dade county, another with Haralson, and a third with Muscogee."

We are glad to see that this State, although the last in the Union, except Florida, to commence the systematic survey of her mineral wealth, is pushing forward the work so well begun last year. It has long been needed, and is evidently in good hands. The results above noticed are of great interest, and we shall look rather impatiently for the detailed reports "now in preparation." This work in Georgia fills the only blank hitherto existing

in our knowledge of the *general* structure of the Appalachians; and its vigorous prosecution promises soon to furnish all the more especially desirable *detailed* information concerning the area within that State.

4. *Geological Survey of Illinois*, A. H. Worthen, Director. Vol. VI. *Geology and Paleontology:* Geology, by A. H. Worthen and Assistants, G. C. Broadhead and E. T. Cox; Paleontology, by O. St. John, A. H. Worthen and F. B. Meek. 532 pp., roy. 8vo, with 34 plates. Springfield, Ill., 1875.—This sixth volume of the Illinois Geological Report commences with a chapter, by Mr. Worthen, on the Coal-Measures of the State, which cover 35,000 square miles, and have a thickness of about 1,400 feet. A detailed section, given on pages 2 to 5, includes 16 beds of coal, large and small, with intervening marine beds, proving that each era of terrestrial vegetation was followed by one of marine submergence and abundant marine life. This chapter on the Coal-Measures is followed by others on the special geology of several of the Counties of the State.

Part II continues the reports on the Paleontology. The Vertebrate portion is by Messrs. St. John and Worthen, and the Invertebrate by F. B. Meek. Previous volumes contain descriptions and figures of a large number of new Paleozoic species of fossil plants, Mollusks, Crinoids, and Fishes, with several of Corals, Crustaceans, Myriapods, Scorpions, Insects and Amphibians. This new volume adds largely to the new species of fishes and Crinoids, and somewhat also to those of Mollusks. The contributions of the Survey, through its paleontologists, to the departments of fossil fishes and crinoids greatly surpass all that have been made by other State Surveys; and those of Crinoids are unequalled by the publications of any other country. The number of new species of fishes described, from the teeth, in this sixth volume alone, is over 100 (divided nearly equally between Hybodonts and Petalodonts, with one Cochliodont), and besides these there are 45 species of fish-spines. The plates are full of excellent figures beautifully engraved.

Mr. Worthern states that with this volume the series of reports closes, the "law-making power" desiring "to cut off all appropriations not deemed by them absolutely necessary;" but that there are many fossils yet undescribed, including nearly all the corals and bryozoans, and many common fossils.

The Reports issued make a most honorable exhibit of the liberality of the State; yet the fact that the volumes are so full and excellent in all respects excites the earnest desire that the remaining volume should be issued which would make the series complete.

5. *U. S. Geological Survey of the Territories under* Dr. F. V. Hayden. (1.) *Bulletin No.* 6.—This new Bulletin contains the following papers: (1) An account of the various publications relating to the travels of Lewis and Clarke, with a commentary on the results of their expedition, by Dr. E. Coues; (2) Notice

of a very large Goniatite from Eastern Kansas, by F. B. MEEK; (3) Fossil Orthoptera from the Rocky Mountain Tertiaries, by S. H. SCUDDER; (4) Studies of the American Falconidæ: a monograph of the Polybori, with five plates, by R. RIDGWAY. Dr. Coues gives a critical review of the spurious and genuine works that have purported to give the results of the travels of Lewis and Clarke over the Rocky Mountain region, and closes with notes on the Zoology of the expedition. The Goniatite described by Mr. Meek must have had, he observes, a diameter in one direction of sixteen inches; it is a globose species, and is made var. *excelsus* of the Illinois species *G. globulosus*, M. and W. The fossil *Orthoptera*, in Mr. Scudder's paper, are a cockroach, *Homœogamia ventricosus*, and an earwig, *Labidura tertiaria*.

This sixth Bulletin contains a general index to Nos. 1 and 2, first series, and Nos. 1 to 6, second series, and thus closes the first volume.

6. *Geological Sketches by L. Agassiz.* Second series. 230 pp. 12mo. Boston, 1876. (James R. Osgood & Co.)—Geological science owes to Agassiz the first distinct announcement of the glacial origin of the northern drift, and also the collection and publication of facts from Europe and North and South America establishing the truth of his theory. This beautifully printed volume contains some of his recent papers on the subject, as they were written out, in a popular form, for the Atlantic Monthly. The chapters treat, severally, of "the Glacial period;" the "Parallel Roads of Glen Roy, in Scotland;" the "Ice-period in America;" "Glacial phenomena in Maine;" and the "Physical History of the Valley of the Amazon." They consist of clear and vivid descriptions and reasonings from one who had seen the facts and scenes he describes, and whose mind was large enough to appreciate their significance and grandeur. We think that Professor Agassiz has attributed too wide a range to the ice-covering of the Glacial period in making it extend over the tropics. But if not right in this opinion, his chapter, on the valley of the Amazon, will still be read with interest and profit.

7. *Geological Survey of Victoria. Report of Progress;* by R. BROUGH SMYTH, Secretary for Mines and Chief Inspector of Mines for the Colony. No. II; with Reports by A. W. Howitt, R. A. F. Murray, R. Etheridge, Jr., N. Taylor, F. M. Krausé, W. Nicholas, G. H. F. Ulrich, J. Cosmo Newberry. 142 pp. Royal 8vo, with views and sections. Melbourne and London. Also, *Observations on New Vegetable Fossils of the Auriferous Drifts;* by BARON F. v. MUELLER. 32 pp. royal 8vo, with maps and plates of figures of fossil plants.—The earlier Reports of the Victoria Survey are noticed in vol. ix, (1875) of this Journal. From the Report of Mr. Smyth we take the following facts. The area of the auriferous grounds of Victoria is about 680,000 acres. The mining surveyors report that there are 3,398 distinct auriferous quartz veins, which have been investigated, besides many others unexplored; and some have been traced for seven miles. One is worked to a depth of 1,000 feet, and another goes down 200 feet

below the sea-level and yields more than one ounce per ton. In 1874, 6,725 tons of auriferous pyrites yielded 18,911 ounces of gold.

The vegetable fossils described by Baron F. v. Mueller are fruits, of kinds unlike existing Australian species, and all are referred to new genera. They come mostly from the auriferous drifts at a depth of about 150 feet, and are referred to the "Pliocene." They include fruits of *Spondylostrobus*, cypress-like conifers; of *Trematocaryon*, supposed to be related to the Verbenaceæ; of *Rhytidotheca*, allied to Chloroxylon; of *Plesiocapparis*, near Capparis; of *Celphina*, supposed to be Proteaceous and most allied to Helicia of East and North Australia; *Odontocaryon*, not referred to any natural order, the author "being unaware of any existing or extinct genus to which it bears really close resemblance;" of *Conchotheca*, having fruit like that of Grevilleæ, but not certainly Proteaceous; of *Penteune*, a large nut, but of doubtful relations; of *Dieune*, perhaps related to Capparideæ or Pittosporeæ; of *Platycoila*, of doubtful relations.

8. *Glacier phenomena along the Kittatinny or Blue Mountain, in Carbon, Northampton and Monroe Cos., Pennsylvania.*—Mr. C. E. Hall describes extensive deposits of gravel and bowlders south of the Lehigh Gap and along the Lehigh River; and also at Wind Gap, and the Delaware Water Gap. Four miles from the mouth of Marshall's Creek, on the road to Craig's Meadow, there are scratches on the Oriskany sandstone, having the direction S. 28° W.—which is toward the gap, following the course of the river. Mr. Hall also shows that the gravel deposits in and about the city of Philadelphia are glacial. Between Spruce and Walnut streets, west of Forty-fifth street, bowlders of Oneida conglomerate, Medina sandstone, and of other rocks, have been exposed to view which vary from one to twenty-five cubic feet in size, some of them glacier-scratched. He mentions also other localities of bowlders within the city limits.—*Proc. Amer. Phil. Soc.*, xiv (No. 95), pp. 620 and 633, 1875.

9. *Wisconsin Geological Survey.*—The Report on the Geological Survey of Wisconsin is ready for the press and awaits only the action of the legislature. A prospectus of its contents shows that it contains a large amount of valuable material. Prof. T. C. Chamberlin, of Detroit, has been placed at the head of the Survey for the present year.

10. *Frequency of Earthquakes relatively to the age of the Moon.*—Prof. ALEXIS PERREY continues his study of earthquakes, and has recently published in the Comptes Rendus a new statement as to the relation between the age of the moon and the frequency of earthquakes.* Dividing the period of a lunation into quarters, with the time of the syzigies, and quadratures as the centers of these quarters, he finds that the earthquakes are distributed as follows:

* For a translation of a former paper by Prof. Perrey on this subject, see this Journal, II, xxxvii, 1.

	Total.	Syzigies.	Quadratures.	Diff. in favor of the syzigies.
From 1843–1847	1604	850·48	753·52	96·96
1848–1852	2049	1053·53	995·47	58·06
1853–1857	3018	1534·13	1483·87	50·26
1858–1862	3140	1602·99	1537·41	65·98
1863–1867	2845	1463·42	1381·58	81·84
1868–1872	4593	2333·48	2259·52	73·96
1843–1872	17249	8838·03	8410·97	427·06

The reported earthquakes between 1751 and 1843 are shown to conform to the same rule—that is, a large preponderance of earthquakes about the syzigies.

Professor Perrey also finds that of the reported earthquakes between the years 1843 and 1872, 3,290 occurred at the moon's perigee and 3,015 at the apogee.

11. *Fossil Fishes of the Devonian of Tula, and Carboniferous limestone of Mjatschkowa, Russia;* by H. Trautschold (N. Mém. Soc. Imp. Nat. Moscou, xiii, 263, 277.)—The Devonian fish remains here described and figured include Hybodonts of the genus *Cladodus;* Cestracionts of the genera *Orodus*, *Helodus*, *Psammodus;* also species of *Ctenacanthus*. The Carboniferous limestone has afforded the author the Illinois species, *Cladodus lamnioides* of Newberry and Worthen: species of *Helodus*, *Psammodus*, *Pœcilodus*, *Cochliodus*, *Orodus*, *Solenodus*, *Petalodus*, *Dactylodus*, (one of Newberry and Worthen's genera), and *Polyrhizodus;* besides some fish-spines, of which one, *Ostinaspis acuta*, is *Petrodus acutus* N. and W.

12. *On the occurrence of native Zinc.* (Letter to one of the Editors.)—Mr. W. D. Marks of Chattanooga, Tennessee, announces the occurrence of fragments of metallic zinc in the soil along the course of a vein intersecting the blue limestone of Sand Mountain, in the northeastern corner of Alabama. The circumstance is supposed to indicate that the metal came originally from the adjoining rock. Further than this, he states that pieces of metallic zinc have been picked up along a range of thirty miles, over the Racoon Mts. on the southern border of Tennessee, Sand Mt., and the northern portions of Georgia and Alabama. The vein is now being explored, and Mr. Marks hopes to find the zinc in place.

13. *Brookite.*—Exact measurements made by vom Rath upon an excellent crystal of brookite from Atliansk in the Urals show that the mineral from this locality at least is not monoclinic, but orthorhombic. E. S. D.

14. *On the Serpentines of Zöblitz, Greifendorf and Waldheim;* by J. Lemberg in Dorpat.—The chemical examination of the serpentines, from the above mentioned localities in Saxony, by Lemberg, has led to the conclusion that they have arisen from the alteration of rocks consisting originally of chrysolite, garnet and hornblende. An analogous conclusion has been reached by other investigators for similar occurrences. In the case in hand it is shown that the readily-decomposed chrysolite has been changed

for the most part into serpentine; the garnet into minerals of the chlorite group; while the hornblende has generally withstood alteration. The paper of Mr. Lemberg contains a considerable number of analyses showing the composition of the original minerals, as well as of the products of decomposition.—(*Zeitschrift d. Deutsch. geol. Gesellschaft*, 1875, 531.) E. S. D.

15. *Selwynite, Noumeite, Garnierite.*—Mr. G. H. F. ULRICH, in a letter dated Melbourne, Nov. 3d, 1875, states that the new species Selwynite, described by him, is not a homogeneous mineral. A microscopic examination shows it to consist of a felsite-like base, through which hydrous chromic oxide is disseminated, with occasionally a small octahedron of chromite. A similar method of examination has shown that the new nickel minerals (noumeite, garnierite), described by Professor Liversidge, are not homogeneous. There is here a soapstone-like base, composed of hydrous silicate of magnesia through which either hydrous oxide of nickel, or hydrous silicate of nickel is densely distributed in small veins and roundish patches. Some of the ore gave an assay up to twenty per cent of nickel, and others as low as two per cent.

16. *Manual of Geology of J. D. Dana.*—The following changes and corrections (besides some others merely typographical) have been made in the stereotype plates of the work since its first publication in 1874, and are needed by the copies of the earlier issues.

Page xv, 17 l. from top, P. C. Carpenter for J. G. Cooper. Page 3, 8 l. fr. top, 1–1,200,000 for 1-200,000. P. 82, fig. 61f has been inverted; and the same on p. 546. P. 147, 4 l. fr. foot, C. for F. P. 166, under fig., 4a Trenton *for* "4 Trenton." P. 338, 2 l. fr. top, fig. 521, *for* "p. 521." P. 344, in map, 9, 9, 9, *for* "8," "8," "8," and 8 for "9." P. 345, 18 l. fr. top, east *for* "west." P. 419, 4 l. fr. foot, southeast *for* "southwest." P. 427, 3 l. and 4 l. fr. top, over two *for* "three or four." P. 538, paragraph beginning with "The absence" has been changed so as to make it state that between the meridian of 100° in Dakota and the eastern boundary of Oregon and California the mean annual precipitation is not, with small exceptions about the higher mountains, over 16 inches. P. 675, 15 l. and 14 l. fr. foot, former *for* "latter," and latter *for* "former." P. 699, 16 l. fr. foot, yards *for* "feet." P. 743, 18 l. fr. top, along the strike *for* "transverse to the strike;" and for the closing part of the paragraph has been substituted:—an effect due to compression by the pressure to which the rocks had been subjected and a consequent expanding in a transverse direction. P. 756. To the first paragraph has been added the remark [a suggestion to the author by Prof. Verrill] that the retaining of the warm Gulf Stream waters in the Atlantic would give the ocean a higher temperature than it now has, and that this higher temperature would be the occasion of an unusual amount of evaporation, and, therefore, of an extraordinary amount of precipitation and frequency of storms along the cold borders of the continent in the Glacial latitudes; so that the theory adopted for the origin of the cold of the Glacial period accounts for both the cold and the abundant precipitation. P. 589, Cetacean area removed from Cretaceous column. D.

III. BOTANY.

1. *Notes on Agave;* by GEO. ENGELMANN, M.D.—This is a modest title of a paper in the Transactions of the Academy of Science of St. Louis, Missouri, vol. iii, December, 1875. Separately issued it forms a pamphlet of 35 pages, 8vo. If we mistake not it begins that volume; so that the pages of the pamphlet

are those of the volume, as ought always to be the case, for convenience and uniformity of reference.

Dr. Engelmann deserves high praise and many thanks for taking in hand, one after the other, our difficult botanical subjects, concentrating his attention upon them for a while, elucidating them to the full extent of his opportunity, and leaving them in such a state that they can be easily understood, or readily followed up as occasion serves, by ordinary observers and collectors. His latest essay of this sort was upon *Yucca.* He passes from that to the analogous American genus, *Agave*, the "American Aloe," first distinguished from the old-world *Aloe* genus by Linnæus, who gave them the present name, *Agave*, "because that word indicates something grand and admirable." The headquarters of the genus are in Mexico, but a considerable number inhabit our southwestern borders, and one reaches well into the northern States. There are "perhaps 100 species,"—possibly a high estimate, but the catalogues of cultivators give twice that number of names. Most of them are nearly unrepresentable in the herbarium, while in cultivation they seldom blossom. The century plant, *A. Americana*, may sometimes in our cool regions literally answer to its popular name: semi-centennial specimens at least are not uncommon.

Dr. Engelmann first devotes a few important pages to the general structure and conformation of the trunk, foliage, inflorescence and fructification in the genus, and passes to a systematic arrangement and description of the N. American species as now known to him, and of a few extra-limital species upon which he is able to throw some light. They fall into three groups. 1. *Singulifloræ*, with flowers in a simple spike, a single one to each bract. Our northern *Agave Virginica* is the familiar representative: there are also *A. maculosa* of Texas, and *A. variegata* from just over the border, both in cultivation. 2. *Geminifloræ*, with a denser spike, a pair of flowers to each bract. Our species are arranged by obvious characters of the margin of the leaves, viz: with rough serrulate margins, *A. falcata*, n. sp.; with filamentose margins, *A. Schotti*, n. sp., and *A. parviflora*, Torr.; with aculeate-toothed margins, *A. hetearcantha*, Zucc. (which is Torrey's *A. Lechuquilla*), and *A. Utahensis*, Engelm. 3. *Paniculatæ*, the typical Agaves or Century-plants, with paniculate inflorescence. There is a division with tube of the perianth much shorter than its lobes. Under this *A. Newberryi*, n. sp., is marked by the insertion of the stamens on the base of the tube. The others, with stamens borne in the throat, are *A. deserti*, n. sp., *A. Parryi*, n. sp. (doubtfully regarded by Dr. Torrey as a variety, *latifolia*, of *A. Americana*), and *A. Antillarum* Desc., with orange-yellow flowers, now elucidated from materials brought from San Domingo by Parry and Wright in 1871. The division with tube of the perianth shorter than its lobes, and bearing the stamens about its middle, contains a very striking species, *A. Shawii*, from the southwestern corner of California, which, having broad and deep-green leaves with a

brown horny margin, set off by the large light red-brown spines, is thought to be one of the finest of the genus for ornamental cultivation. It was discovered by Dr. Parry in 1850, but good specimens only now obtained, and it is appropriately dedicated to the founder of the Missouri Botanic Garden, from which much is confidently expected. Finally, there is a division known by the tube of the perianth equaling the lobes or hardly shorter, and bearing the stamens: to this belong *A. rigida* Miller, with the Yucatan doubtful variety, *Sisalana*, introduced nearly forty years ago into S. Florida by the unfortunate Dr. Perrine; *A. Palmeri*, n. sp., from S. Arizona; and *A. Wislizeni*, n. sp. (which has had the utterly false name of *A. scabra* in Germany) in Northern Mexico. A reference to one or two very imperfectly known species is appended. Of *A. Americana*, there is a mere mention that it has a stipitate capsule.

In all species, so far as known to Dr. Engelmann, the anthers discharge their pollen about forty-eight hours before the style matures and the stigma can receive pollen. After the expansion of the lobes of the latter, at least in *A. Virginica*, a viscid liquid fills the cavity of the apex of the style, "whether stigmatic, or only intended to allure insects, has not been ascertained." The figures which so commonly represent bursting anthers and a fully elongated style in the same blossom are probably factitious, as they certainly are in many otherwise excellent plates of various kinds of flowers. In conclusion, those who have the opportunity to examine species of *Agave* in flower are particularly requested to note at what hour of the day the anthers begin to shed their pollen, and at what time they become effete, and in what state the style is at these periods. The anthesis, so far as Dr. Engelmann has observed, is vespertine or nocturnal, as well as proterandrous. The time and nature of the nectariferous secretion in the lower part of the flower should also be recorded. A. G.

2. *Structure of the Leaves of Grasses: Histotaxie des feuilles de Graminées;* par J. Duval-Jouve.—An elaborate article in Ann. Sci. Nat., tome i, of Ser. 6, 1875, with four admirable plates of anatomical details. It appears to be an excellent piece of work, upon an almost neglected subject. Many of the text-books still say of the leaves of grasses, and indeed of Monocotyledons generally, that their veins or nerves are simple and unconnected by anastomosis; although what was meant must have been that the only anastomosis was by ultimate transverse veinlets. Duval-Jouve cites a long list of grasses in which these are conspicuous; and there are many in which the reticulating veinlets are of different orders. The stomata of grasses are in some confined to the lower surface of the leaf; in others divided between the two faces; in several they are restricted to the upper face, but in these the blade makes a turn or twist, so as for the most part to present this upper surface to the ground. *Triticum junceum*, *Calamrogastis* (*Psamma*) *arenaria*, and *Gynerium argenteum* (Pampas Grass) are cited as instances. Many grasses have under the epidermis of their upper

face, and sometimes of the lower also, rows or bands of large thin-walled cells, which our author names *bulliform* cells. These in their presence, absence, number, and arrangement, are uniform in each species, but often quite different in the same genus, so that they may be used for critical specific characters; and they are, moreover, connected invariably with the vernation of the leaf, and with the opening and closing (either by conduplication or convolution, according to the vernation of the species) which are so prompt in many grasses. That this movement takes place in virtue of the hygrometric expansion of these cells under moisture and their contraction in dryness, was made plain by the behavior of sections of the leaf under the microscope, the closed conduplicate leaf of *Sesleria* opening instantly upon the application of a drop of water, when these cells in a band on each side of the midrib, before flattened or collapsed, became turgid and prominent. The leaves of *Leersia oryzoides* are described as rolling up instantly upon being bruised or roughly handled, as if endowed with real irritability. We trust some of our young botanists will look to this, next summer.

The split sheath of the leaves is one of the diagnostic characters of the *Gramineæ*. Exceptions in *Glyceria*, &c., were familiar. M. Duval-Jouve states that about a fifth part of the species have entire sheaths. Also that various grasses bear two, three, and even four leaves on one node! A. G.

3. *Botryopteris Forensis*, an interesting fossil fern, which occurs with fructification preserved in a silicified state in the rich deposits of Autun and Saint Étienne, France, has recently been investigated microscopically by B. Renault (Ann. Sci. Nat., 6 ser., i, 1875). In one plate he has illustrated the anatomy of the stem; in four others its fructification, and the anatomy, developing fructification, &c., of a *Trichomanes*, a *Helminthostachys*, and a *Botrychium*, for comparison. He concludes that in this fossil genus we have a type intermediate between true *Filices* and the *Ophioglosseæ*. A. G.

4. *Silicified fossil Fruits or Seeds*, from the coal beds of St. Étienne, are discussed by Brongniart in a preceding volume of the Ann. Sci. Nat. (with figures), and classified by the form of their transverse section. They are thought to be gymnospermous. Among those with binary symmetry, *Cardiocarpus* in its affinity is thought to answer to *Salisburia*; *Rhabdocarpus*, a new genus, to *Torreya*; *Diplotesta* and *Sarcotaxus* (new genera), to *Cephalotaxus*; *Taxospermum* and *Leptocaryon* to *Taxus*. Those of radiate symmetry of three, six, or eight divisions or a circular section, of various kinds, including *Trigonocarpus*, are conjectured to be the fruit of *Sigillaria*, *Calamodendron*, and the like, which Brongniart takes to be an extinct type of Gymnosperms. A. G.

5. *Respiration of Plants; some Researches by* Mayer and Wolkoff: a paper in Ann. Sci. Nat., in the volume above cited; apparently translated from a prior publication in German, to which there is no direct reference. That plants have a true res-

piration like that of animals, correlative with decomposition, is so well made out of late years, (and besides is understood to be inevitable if the plant is to do any work), that it was hardly necessary to refer back to a work of Liebig fourteen years old, and even then a little antiquated, for an enunciation of the opposite doctrine. Then the process answering to respiration was overlooked or thought unessential, being overshadowed by the vaster, larger and more important counterpart process of assimilation. The researches of which the results are given in this paper were made to ascertain the relations between vegetable respiration, i. e., the expiration of carbonic acid, and light, temperature, growth, &c. The results, on the whole, were, that changes of temperature within normal limits were of little effect and transient when the change was sudden; that the influence of light, although generally appreciable, was feeble, and probably indirect. This action, as is well known, goes on both in light and darkness, but under the latter it is not masked by the assimilative process. Growth also proceeds indifferently under either, or, it would appear prefers darkness. But Mayer and Wolkoff conclude (contrary to some of their predecessors) that there is no direct relation between growth in length and respiration, so that one should in any sense serve as the measure of the other. A. G.

6. *Classification of Nostochineæ.*—Dr. Bornet, in a recent number of the Annales des Sciences Naturelles, has published a most useful key to the genera of the *Nostoc* tribe, which was drawn up by the lamented Thuret, shortly before his death. Although it was not intended for publication in its present state, it cannot but be useful. The appended enumeration mentions most of the species, with leading synonyms. A. G.

7. *Gymocladus in China.*—If M. Baillon is right in his identification by means of pods and loose flowers, there is a second species of *Gymocladus*, our Kentucky Coffee-tree, indigenous to China, in the vicinity of Shanghai, where the gummy substance in the legume is used as a substitute for soap. This is an additional instance of a supposed monotypic genus of Atlantic North America being represented in the corresponding part of N. E. Asia. Baillon's notice of it is in Bull. Soc. Linn., Paris, Jan., 1875. A. G.

8. *Flora Brasiliensis*, fasc. 68, issued in March, 1875, has just come to hand. It contains the *Amarantaceæ*, by Prof. M. Seubert of Carlsruhe, with 26 plates; and this fascicle completes vol. v, part 1. There are 13 Brazilian genera; of which much the largest is *Gomphrena*, with 66 species. The species figured which concern the North American flora are *Alternanthera achyrantha* and *Amarantus hypochondriacus*.

9. *Das Haustorium der Loranthaceen und der Thallus der Rafflesiaceen und Balanophoreen;* von H. Grafen zu Solms-Laubach. Halle, 1875. 4to. The present paper is supplementary to an article on the vegetative organs of phanerogamic parasites which appeared in Pringsheim's Jahrbücber, Bd. vi. The writer divides his subject into three parts. The first is

devoted to a consideration of the modes of attachment of different species of *Loranthaceæ* to the foster plant. This is accomplished by the growth inward of suckers (*Saugfortsätze*) which penetrate through the bark to the wood. The shape which any sucker assumes depends on the relative activity of the growth of the sucker itself and of the cambium. In some cases, as *Loranthus Europæus* and *L. Sternbergianus*, the sucker sends out processes which penetrate into the wood itself. The writer confirms the suggestion made by John Scott that the vascular bundles of the parasites communicate with those of the plants on which they are growing.

Part II is devoted to the vegetative organs of the *Rafflesiaceæ*, which had previously been studied only in *Pilostyles Haussknechtii* Boiss. and *Cytinus Hypocistus* L. The writer gives the results of his examinations of *Pilostyles Æthiopica* Hook., *P. Blanchetii* Gardn., and *P. Caulotreti* Karst., which closely resemble one another. The vegetable organs of these species consists of threads or, at times, flat expansions which are found in the last and from which suckers are given off which penetrate into the wood. The name given to the thread-like expansions is thallus, from its resemblance to the structures of the same name in cryptogams. The flower buds are produced as adventitious offshoots from the threads of the thallus, and finally burst through the bark of the foster-plant. *Pilostyles Thurberi* A. Gray, a plant of our own country which is parasitic on species of *Dalea*, differs somewhat from other species of the genus. Its thallus, which is found in the inner bark, is not composed of threads but of flat expansions of considerable size. They are at first destitute of vessels, which, however, make their appearance about the time of the formation of the flower buds. Part III is devoted to the vegetative organs of the *Balanophoreæ*, and the writer concludes as follows: "It is the object of the present essay to call attention to the fundamental uniformity of the development and conformation of the assimilating organs of the phanerogamic parasites. This object has been attained if we have been successful in showing that they all have a common characteristic in the absence of any sort of differentiation of organs of vegetation such as we find in the *Cormophytes*, that their organs can be neither roots nor stems, but that we are compelled to recognize them as thalline structures equivalent and completely analogous to those of the Thallophytes. This would have pleased Lindley, as indicating a structural foundation for his class of *Rhizogens*. W. G. F.

10. *The Movements and Habits of Climbing Plants;* by CHARLES DARWIN, M.A, F.R.S., etc. 2d ed., revised, with illustrations. 208 pp. 8vo.—This work by Darwin, noticed at page 69 of this volume, has recently been republished by D. Appleton & Co., New York.

IV. Astronomy.

1. *A series of Astronomical Drawings for the Centennial Exhibition.*—A unique feature of the Centennial exhibition will be a series of thirty-six Astronomical drawings of interesting celestial objects, executed in pastel by L. Trouvelot, the artist who produced the series of Astronomical engravings undertaken by Professor Winlock at Harvard College Observatory. The pictures vary in size between eighteen by twenty-two inches, and twenty-three and one-half by twenty-eight and one-half inches, exclusive of the frames. The following have already been completed, viz: Nebula in Orion, Nebula in Andromeda, Horse-Shoe Nebula, Winged Nebula, Trifid Nebula, Ring Nebula, Dumb-Bell Nebula, Cluster in Hercules, Coggia's Comet, the planets, Mars, Jupiter and Saturn, Sun-Spots in full activity, Solar Protuberance eruptive form, Solar Surface with Chromosphere, Protuberances and Corona, Aurora Borealis, Group of Sun-Spots with bridges, Milky Way in two parts, Zodiacal Light, Shower of Shooting Stars, and Tempel's Nebula in the Pleiades. The original sketches have been for the most part made with an excellent refractor, of six and one-half inches aperture, mounted in Mr. Trouvelot's Physical Observatory at Cambridge. Their production has been a work of immense labor. From fifteen to twenty-five nights have been spent in the study of each nebula. The sketch of Tempel's Nebula in the Pleiades is the result of sixty-five hours' study. In the drawings of the Milky Way, the stars are plotted with considerable accuracy. Over a year was spent in the preparation of these two sketches. Of the sun-spots, protuberances, auroras and the zodiacal light, the most typical forms have been represented. In the shower of falling stars, every one represented was observed on the night of Nov. 13, 1869. It is Mr. Trouvelot's design to make these drawings available at the close of the exhibition, in producing a series of Astronomical Charts for educational purposes.

W. A. R.

2. *Our Place among Infinities;* by Richard A. Proctor. 324 pp. 8vo. New York, 1876. (D. Appleton & Co.)—This work consists of "A series of essays contrasting our little abode in space and time with the infinities around us," with also "Essays on the Jewish Sabbath and on Astrology." Mr. Proctor aims, in his various works, to put science, especially astronomical science, in an attractive form for the general reader. In presenting his subjects he does not always make it clear as to what are speculations and what known facts; but he is dealing with the marvellous, and this method in his hands makes things the more marvellous. His range of knowledge is considerable, and his style perspicuous and forcible. Astronomers would not accept of all his conclusions, neither would geologists, and probably not biblical critics. After perusing his note on the origin of crater-cavities on the moon's surface by the blows of meteorites, or the passage (p. 84) in which

he describes the encounter and destruction of a comet by a meteoroid stream, the reader will probably be led to question his judgment on other topics.

V. Miscellaneous Scientific Intelligence.

1. *Mt. St. Elias.*—In a notice of Mr. W. H. Dall's paper on Mt. St. Elias (from the Coast Survey Report for 1875) on pp. 77 and 78 of this volume, the remark is made that the views are evidently vertically exaggerated. The author has informed us that the proportions of the mountains are rightly given, from determinations by instruments. The view of Mt. St. Elias was taken from Yakutat Bay (Port Mulgrave), 53 [nautical?] miles to the southeast. The southern face of the mountain, from a line about 5,000 feet above its base, is "an immense rock-face, inclined at an angle of 45° to the sea, and rising 8,000 to 10,000 feet without a break in its continuity." "The apex is pyramidal, sharp and clearly cut, leading to the inference that it is precipitous on the invisible northern side. The whole of the rock-face is marked by straight rigid lines of bedding, which are inclined uniformly to the eastward at an angle of about ten degrees." Mr. Dall concludes from its features and this appearance of stratification, that the mountain is not volcanic but consists, with the high range to which it belongs, mainly of non-volcanic crystalline rocks.

The height of Mt. St. Elias was determined trigonometrically by measurements from four stations, that at Port Mulgrave, 69 miles distant from Mt. St. Elias, and the others (off Lituya Bay, off Dry Bay, and at sea to the south-southwest) over 100 miles distant. The following are the angles of altitude from each station, and the calculated height:

1. From Port Mulgrave,	69·11	miles	distant,	2° 38′ 1″	19,464 feet.
2. Off Lituya Bay,	167·62	"	"	0° 9′ 5″·1	18,033 "
3. Off Dry Bay,	132·25	"	"	0° 50′ 8″·1	19,956 "
4. At Sea,	127·25	"	"	0° 47′ 34″	18,350 "

It is time that the geology and altitude of Mt. St. Elias were determined by observations made on the mountain itself.

J. D. D.

2. *Harbors of Alaska and the Tides and Currents in their vicinity;* by W. H. Dall, Assist. U. S. Coast Survey. From the Coast Survey Report for 1875; Appendix No. 10. *Report of Geographical and Hydrographical Explorations on the Coast of Alaska;* by W. H. Dall. Ibid; Appendix No. 11.—The first of these papers contains new facts on the tides, currents, ocean and land temperatures, hydrography, topography and other characteristics of the vicinity of Alaska and some of the Aleutian Islands. The Shumagin Islands, south of the extremity of the Alaska Peninsula, are described as composed of granite, various metamorphic rocks and sandstones, overlaid by Tertiary beds, "of which the upper beds contain fossiliferous layers of Miocene age, the lower ones containing remains of warm temperate vegetation, and the

uppermost remains of marine animals, including mollusks and cetaceans." There are also recent lavas.

The second paper contains, besides geographical and hydrographical observations, tables of magnetic declinations at positions among the Aleutian Islands, according to different observers, including new results obtained by the Coast Survey. From them it appears that there is a decrease of the easterly variation at the stations where observations have been taken, when the results are compared with those heretofore published. The following are some of the results obtained:

At Amchitka Island, Constantine Harbor, 51° 23′ 32″·9 N., 179° 12′ 12″·2 E., variation 7° 15′ 33″ E.

At Chichagoff Harbor, Attu Island, 52° 55′ 57″·23 N., 173° 12′ 22″·2 E., variation 7° 44′ 36″ E.

At Kyska Island, 51° 58′ 59″·11 N., 177° 29′ 46″·3 E., variation 11° 06′ 27″ E.

At Adaka Island, Bay of Islands, 51° 49′ 15″·6 N., 176° 51′ 58″·2 W., variation 13° 52′ 03″ E.

At Unalaska Island, Iliuliuk village, 53° 52′ 37″·7 N., 166° 31′ 36″ W., variation 18° 59′ 44″ E.

At Shumagin Island, Popoff Straits, 55° 19′ 16″·7 N., 160° 31′ 14″·1 W., variation 20° 29′ 23″·7 E.

3. *Memoirs of the Peabody Academy of Science*, Vol. I, No. 4. 94 pp. Roy. 8vo, with plates. Salem, Mass., Dec. 1875.—This fourth number of the "Memoirs" is occupied with a paper by the late Dr. Jeffries Wyman, on the Fresh-water Shell Mounds of the St. John's River, Florida.—The facts published by Dr. Wyman in former articles are here brought together along with the results of new observations by him, and they are presented with the usual thorough and cautious method of the author. The mounds are often five or six hundred feet in length, and vary from a few feet to eighteen or twenty in height. Dr. Wyman, after a full description of them, states as his conclusions, that, at the least, two or three hundred years, and probably more, have passed since they were finished; that the fact that the human bones are broken in the same manner as the bones of edible animals proves the makers to have probably been cannibals; that fragments of pottery, while common in the later mounds, are not found in the older; that stone implements are few in the older mounds and rudely made; that the shell heaps contain fragments of the Mastodon, Elephant, Horse, Ox, and some other extinct animals, but that these show by the changes they have undergone, that the animals were not cotemporaries of the mound-builders; that the only skull found differs from the skulls of the Indian burial mounds of the country, in being longer, with the ridges and processes more pronounced, and that among the bones of two other individuals the tibia was flattened; that, while it is uncertain whether the makers of the mounds were the same people that were found there by the Spaniards and French, the absence of pipes and pottery, and the rarity of ornaments, are consistent with the conclusion that they were a different people.

4. *Annual Report of the Chief of Engineers to the Secretary of War for the year* 1875. Part I, 990 pp. 8vo. Part II, 1254

pp.; each with many maps and illustrations.—The Annual Report of the Engineering Department is of high importance in a scientific point of view. Besides details as to work done in the improvements of harbors and rivers, and discussions of the methods of carrying on such improvements, it contains a great amount of new information, on the geography, resources and trades of the regions examined, results of hydraulic investigations, discussions of the modes of wear, transportation and deposition by rivers, the topography, and on the productions and resources of the territories, besides facts and views on other topics.

Among the articles in the Report for 1875, the following are especially noteworthy: Major Warren's Report on the Minnesota River, which is both historical, descriptive and geological, and contains a map showing the Mississippi when Lake Winnipeg was its head (this Journ., ix, p. 313); Commissioner H. L. Abbot's analysis of the Mississippi floods; Gen. T. G. Ellis's Report on the Connecticut River, in which the amount of discharge of the river at Hartford is given for each day, from Feb. 1, 1871, to Dec. 31, 1874, and, as an incidental result, the parabolic form of the curve of subsurface velocities in a river, as made known by Humphreys and Abbot (in their Report on the Physics and Hydraulics of the Mississippi), is fully confirmed by observations at Thompsonville; Col. Gilmore's Report on the compressive strength and specific gravity of the building stones in the United States in most general use; Report of Clarence King with reference to the geological exploration of the 40th parallel; Report of Lieut. G. M. Wheeler, on geographical explorations and surveys west of the 100th meridian, noticed beyond; and Col. Ludlow's Report on the expedition to the Black Hills, already noticed in this Journal.

5. *Annual Report upon the Geographical Explorations and Surveys west of the* 100*th Meridian;* by GEORGE M. WHEELER, 1st Lieut. of Engineers U. S. A. 196 pp. 8vo. Washington, 1875.—This report is included in the Annual Report of the Chief of Engineers for 1875, as above mentioned. Besides the Report on the Geographical, Geodetic, Hypsometrical, Astronomical and Meteorological work of the survey, this volume contains the following: a discussion on Aneroid barometers; a Report on the Geology of part of northwestern New Mexico examined in 1874, by E. D. Cope, containing, besides geological observations, descriptions of fossil vertebrates of the Santa Fé Marls, on the *Typothorax coccinarum* Cope, from beds supposed to be Triassic (already noticed in this Journal, III, vol. x, p. 153), on the Eocene plateau, and a list of fossil vertebrates from beds of the horizon of the Green River horizon; Geological and Mineralogical Report, by O. Loew, on portions of Colorado and New Mexico; Preliminary Botanical Report, by Dr. J. T. Rothrock; Report upon the Agricultural resources of northern New Mexico and southern Colorado, by Dr. O. Loew, in which several analyses of soils, plants, etc., are given; general itinerary by Surgeon H. C. Yarrow; Ornithological notes, by H. W. Henshaw, and also by Mr. C. E. Aiken; Report on the

Remains of population observed on and near the Eocene plateau of northwestern New Mexico, by E. D. Cope, illustrated by a number of wood-cuts giving plans of structures; a report on the ruins of New Mexico, by O. Loew, and also another, by Lieut. R. Birnie, Jr.; on the Pueblo Languages of New Mexico, and of the Moquis of Arizona, by A. S. Gatschet.

Dr. Loew's papers contain analyses of the basalt of Abiquin, of a zeolite, of garnets from the region of the "memorable diamond excitement," chrysolite, the green feldspar of Pike's Peak, soils and grasses.

6. *Geological Survey of the Territories, under the Interior Department*, Dr. F. V. Hayden in charge.—(1.) *New Publications to be issued during the year* 1876. The following publications connected with the U. S. Geological Survey of the Territories under the direction of Prof. F. V. Hayden, are in press, and will be issued during the year 1876: 1. The Invertebrate Palæontology of the Western Territories, by F. B. Meek, making Volume IX of the quarto series. It will contain 600 pages of text and 45 plates; over 500 pages are already printed. 2. The Fossil Flora of the Lignitic Group, by Leo Lesquereux, making Volume VII of the quarto series. It is illustrated by 65 plates. 3. Monograph of the North American Rodentia, by Messrs. Coues and Allen, to constitute Volume X of the quarto series, and to contain numerous plates. 4. Monograph of the Geometrical Moths, by Dr. A. S. Packard, to constitute Volume XI of the quarto series. It will be illustrated by 13 plates, some of which contain from 75 to 100 figures. 5. Ethnography and Philology of the Hidatsa Indians, by Dr. Washington Mathews, U. S. A. This volume is now passing through the press, and will prove one of great interest; it will contain about 500 octavo pages. 6. Annual Report of the U. S. Geological Survey for 1874, in octavo, now in the press. 7. The Annual Report of the Survey for 1875, which will go to press about May 1st. 8. Bulletin of the Survey for 1876, Volume II. This volume will be issued in numbers, and will comprise about 200 pages of text, with 30 octavo plates. The ancient remains of Southern Colorado, Utah and Arizona will be described by Messrs. Holmes and Jackson. It will also contain an important paper on the ancient skulls, with numerous illustrations. Other volumes are in process of preparation, and may be printed before the end of the year.

(2.) *Descriptive Catalogue of the Photographs*, W. H. Jackson, Photographer. The Catalogue of photographs of the Survey is enlarged in this edition by a list of those taken during the past year. These include three series: one, of the very unusual size of twenty by twenty-four inches; another, measuring five by eight inches; and a third, stereoscopic. The first, as we know from an examination of them, are of unusual beauty and perfection—the largest and grandest the Rocky Mountain region has yet afforded. Those of the second series, fifty-six in number, include many views of the ancient stone cliff ruins and cave towns of the San Juan

region, besides others of the Moquis adobe villages, and many landscapes; and all are admirable specimens of the photographic art. The country owes much to the Survey under Dr. Hayden for the knowledge of the Rocky Mountain territories which has been distributed through the country by means of its numerous and excellent photographs, as well as through its Reports.

(3.) *Models.* To the Survey, the science of the country is indebted also for a model in plaster of the Elk Mountains. It is made on a scale of 1 inch to a mile, aud corresponds to an area of 200 square miles. One copy is to be colored to show the actual features of the region, and thus to exhibit its geological structure. The model has been prepared by the artist, W. H. Holmes. The same artist has executed a model of one of the two-story cliff houses of the San Juan Region, and another of a ruined village in southwestern Colorado. The cliff in the former has a height above the house of 200 feet vertically. (See Bulletin, 2nd Ser., No. 1, p. 20.) A model of a cliff house in Arizona has been made by the Photographer of the Expedition, Mr. W. H. Jackson, on a scale of six feet to an inch. The model is colored so as to represent exactly the appearance of the ruins. Still other models are in course of preparation. We learn that copies of these models will be furnished at cost to institutions desiring them.

7. *Specific gravity Balance of R. Parish.*—A balance, constructed on the same principle with that brought out by Mr. Parish, of Worcester, Mass., in the number of this Journal for last November, has been described and figured by President F. A. P. Barnard, in the second volume of Johnson's "New Universal Cyclopedia," published two or three months since in New York. It appears also that its author presented a paper on the instrument to the National Academy in November, 1874.

A charge of plagiarism on the part of Mr. Parish has been thrown out. The editors of this Journal deem it a duty to say that they know the charge to be without foundation. The paper presented to the National Academy has never been published, and even the editors knew nothing of it. Mr. Parish communicated with them on the subject of his balance first in February, 1875, more than a year since; and Prof. Thompson of the Institute of Industrial Science at Worcester has recently published the statement that Mr. Parish showed him a model of his balance in October, 1874, or before the time of the meeting of the National Academy above referred to. Moreover, Mr. Parish's paper in this Journal was in our hands a month before the publication of the 2nd volume of Johnson's Cyclopedia.

8. *Bulletin of the Bussey Institution*, Harvard University, Jamaica Plain. Part iv, pp. 285–372. 1875.—This fourth part of the Bussey Institution Bulletin contains the following papers: Applied Zoology; the importance of its study to the practical agriculturist, by D. D. Slade, M.D.; Report of the Director of the Arnold Arboretum, presented to the President and Fellows of Harvard University; A record of trials of various fertilizers upon

the plain-field of the Bussey Institution, results obtained in 1874, by F. H. STORER; the potato-rot, by W. G. FURLOW; A report on some Analyses of salt marsh hay and of bog hay, by F. H. STORER; On the fodder value of Apples, by F. H. STORER.

In his memoir upon the composition of hay prepared from the natural grasses of the salt marshes on the seaboard, and of the fresh-water marshes, or "meadows," in the interior, Prof. Storer gives the following analyses:

Name of the Hay.	Water.	Ash (free from C and CO_2)	Albuminoids.	Carbohydrates, including fat.	Cellulose.	Dry Organic Matter.	Fat, i.e., Matters soluble in Ether.
Better kinds of Salt Hay from brackish marshes,	8·23	7·06	7·47	44·53	32·71	84·71	2·94
Black Grass Hay (*Juncus bulbosus*),	8·71	5·19	6·79	46·15	33·16	86·10	2·30
Rush Salt Grass (mean of two samples),	8·65	6·74	4·63	46·67	33·31	84·60	1·76
The coarse Salt-Marsh Grass (*Spartina stricta*),	15·93	10·41	5·09	39·18	29·39	73·67	2·35
Bog Hay (*Carex stricta*) carefully cut and cured in June,	7·40	6·34	9·90	42·61	33·75	86·26	2.17
Bog Hay (*Carex stricta ?*), taken from barns,	8·17	5·54	6·88	45·99	33·42	86·29	2·46
Dead Bog Hay collected in a field in December (*Carex stricta ?*),	9·32	4·42	4·63	41·64	39·99	86·26	0·74
Common Rush (*Juncus effusus*) (taken from a barn),	6·88	2·63	6·75	42·26	41·48	90·49	
Flowering Fern (*Osmunda regalis*) (taken from a barn),	8·23	6·73	7·38	52·07	25·59	85·04	2·97
Buttercups (*R. acris*),	8·24	5·21	10·66	45·19	30·70	86·55	3·64
White Weed (*Leucanthemum vulgare*), cut in flower,	10·87	6·44	7·00	44·69	31·00	82·69	2·42
Beach-pea Vines (*Lathyrus maritimus*),	7·62	7·38	18·70	37·53	28·79	85·01	4·32

In conclusion, Prof. Storer discusses the economical value of rough, low grade hays as compared with the "English" or upland hays.

9. *American Museum, Central Park, New York.*—This Museum is rapidly becoming one of the first of the country in scientific value. With Prof. Hall's collection of fossils, and the addition soon expected of a suite of Barrande's Bohemian species, it will take the lead of all as regards Paleozoic paleontology. The Museum has also very large collections of birds, including the collections of Prince Maximilian of Neuwied and extensive selections from those of M. Verneaux of Paris, and others of shells, insects, etc. The city of New York appropriated $500,000 for a building, and part of it is now completed. Already the persons visiting the Museum occasionally number over 10,000 in a day. The Museum is under the general charge of Professor Bickmore, a former student of Professor Agassiz.

10. *Summer Schools of Zoology and Geology at Cornell University.*—These schools will commence soon after July 7th, and be continued for six weeks. In the Zoological department there will be instruction through lectures and laboratory work, by Prof. W. S. BARNARD, in Mollusks, Radiates, Worms and Protozoans; by Mr. J. H. COMSTOCK, in Insects and Crustaceans; by Prof. B. G. WILDER, in vertebrates, excluding Birds; by Dr. E. COUES, in Birds. Specimens, living or in alcohol, will be furnished the students for study, including "two specimens of *Amphioxus*, one for dissection and the other for preservation." Prof. Wilder will give information concerning the school to those desiring it. The Geological School is under Prof. T. B. Comstock. Instruction will be given by lectures, study of specimens, and by field excursions. Fee for each school, $30.00; $10.00 of it to be paid in April, or on the day of registration, and the rest in July, when the school opens.

11. *Annuaire De La Officina Central Meteorologica De Santiago De Chile*, 1873.—The third and fourth year of the Annuaire of the Central Meteorological Office in Chili gives in detail the observations made at 13 stations during 1871 and 1872; as also an appendix in which is found a very excellent monograph on the earthquake of the 7th of July, 1873, by J. I. Vergara. The preface to the volume, which extends through 280 pages, gives very complete catalogues of earthquakes since 1849, and reviews of the meteorological conditions as shown by monthly and annual means during 1870, 1871 and 1872. The whole constitutes an important addition to our scanty knowledge of the meteorology of that section of the world; and it is to be hoped that Vergara will soon be able to extend the duties of the Meteorological Office, so as to add, to these climatological studies, those other special investigations into atmospheric phenomena, which the peculiar nature of the territory of Chili especially invites. C. A.

Statement and Exposition of Certain Harmonies of the Solar System; by Stephen Alexander, LL.D., Professor of Astronomy, College of New Jersey. Smithsonian Contributions to Knowledge, No. 280. 96 pp. 4to. Washington, D. C., March, 1875.—Professor Alexander's Memoir does not admit of an abstract, and we therefore announce it only, referring to it for his arguments and conclusions.

Half-Hour Recreations in Natural History of Estes and Laureat, Boston. Half-Hours with Insects, by A. S. Packard, Jr. Part 8. pp. 225–256, 1875.

Half-Hour Recreations in Popular Science of Estes and Laureat. No. 16, the Ice age in Britain, by Prof. Geikie, and Causes of the degeneracy of Teeth, by Prof. H. S. Chase. pp. 105–136. 1875.

Förster, E. Geschichte der Italienischen Kunst. Vierter Band. 8vo, pp. 525. Leipzig, 1875. P. O. Weigel.

Wessely, J. E. Anleitung zur Kenntniss und zum Sammeln der Werke des Kunstdruckes. Mit zwei Tafeln Monogramme. 8vo, pp. viii, 338. Leipzig, 1875. P. O. Weigel.

Emile Kopp.—For the biographical notice of Prof. Kopp, on p. 80, this Journal is indebted to Dr. F. H. Storer.

OBITUARY.

GEORGE POULETT SCROPE, the eminent author of works and memoirs on volcanoes, died on the 18th of January, at his residence near Cobhan, Surrey, at the age of 79 years.

APPENDIX.

ART. XXX.—*Principal Characters of the Tillodontia*: by O. C. MARSH. (With two plates.)

THE Eocene deposits of North America have yielded two new orders of extinct mammals, the *Dinocerata*, and the *Tillodontia*, both of great interest, and widely different from all known groups, as well as from each other. The latter order, recently established by the writer,* is comparatively little known, as the animals representing it are of moderate size, and but few of their remains have yet been discovered. The typical genus of this order is *Tillotherium*, the more important characters of which can now be readily determined from specimens in the Yale Museum. This genus, therefore, will be mainly used in the present article to illustrate the order.

Tillotherium Marsh, 1873.†

The skull in this genus resembles in its general form that of *Ursus*. It is of moderate length, much elevated in the frontal region, and with the zygomatic arches widely expanded. (Plate VIII.) The posterior portion of the cranium is depressed, and much constricted behind the fronto-parietal suture. The temporal fossæ are large, and separated by an obtuse sagittal crest. There is no postorbital process. The frontal bones are large, and inflated with air cavities. The nasals are elongate, broad posteriorly, and narrow in front, where they unite with the premaxillaries. The latter are massive, and project forward beyond the nasals. They are united only by a slender bridge of bone, below the anterior narial aperture.

The orbit is confluent with the temporal fossa, which is largely formed below by the squamosal. The latter sends outward and forward a strong zygomatic process, and, downward, a short, obtuse, post-glenoid tubercle, which bounds in front the external auditory meatus. This opening is bounded behind by the posttympanic process of the squamosal, which unites directly with the paroccipital. The tympanic portion of the periotic does not reach the external surface. The articular face for the condyle of the lower jaw is but very slightly concave. (Plate IX.) The malar bone is slender, and forms the anterior

* This Journal, vol ix, p. 221, March, 1875. † Vol. v, p. 485.

portion of the zygomatic arch. The lachrymal is of moderate size, and is perforated by its foramen in front of the anterior border of the orbit. The infra-orbital foramen is large.

The palate is broad behind, narrow in front, and somewhat excavated. The anterior palatine foramina are confluent, and are enclosed between the premaxillaries and maxillaries. The posterior palatine foramina are in the latter bones, near the first premolars. The posterior nares are behind the last upper molars. The occipital condyles are small, and sessile. The exoccipitals are perforated by a condylar foramen of moderate size. There is no auditory bulla, but in its place, an irregular opening, partially occupied by the periotic. There was a distinct alisphenoid canal.

The brain cavity in *Tillotherium* is small, but proportionally larger than in *Dinoceras*.* The size of the brain compared with the entire skull is shown in the accompanying cut, fig. 1.

1.

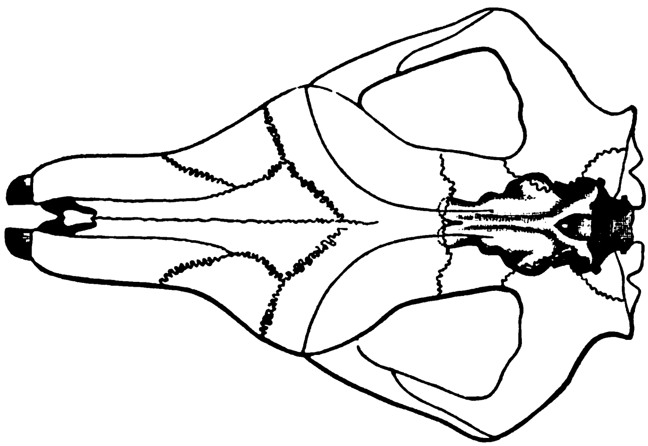


Figure 1. Outline of skull and brain cavity of *Tillotherium fodiens* Marsh. Top view. One-fourth natural size.

As in most, if not all, Eocene mammals, the cerebral hemispheres were small, and did not extend over the cerebellum or olfactory lobes. The latter were large, and projected well forward. The hemispheres were evidently more or less convoluted. There was no distinct tentorial ridge. The cerebellar fossa is large, much expanded transversely, and elevated above the cerebral cavity. There is a shallow pituitary fossa, and no clinoid processes. The exit for the optic nerve is quite large.

The adult dentition of *Tillotherium* is represented by the following formula:

$$\text{Incisors } \frac{2}{2};\ \text{canines } \frac{1}{1};\ \text{premolars } \frac{3}{2};\ \text{molars } \frac{3}{3}.$$

* This Journal, vol. ix, p. 165, Feb., 1876.

The two anterior upper incisors are large and scalpriform, and faced in front with enamel. They grew from persistent pulps, and strongly resemble the corresponding teeth in Rodents. (Plate IX, figure 1.) The upper canines were quite small, and separated by a diastema from the first premolar. In the upper true molars, the fore and aft diameter is much less than the transverse, and the crowns are very short. The form of these teeth is well shown in Plate IX, figure 4, which represents a nearly unworn last upper molar, natural size.

The lower jaw in *Tillotherium* is elongate and massive, and the symphysis is completely ossified. The condyle is broad, convex transversely, and raised above the line of the teeth. The coronoid process is stout, and of moderate height. The angle is thin, and not inflected. The anterior incisors are large and scalpriform, and faced in front with enamel. The canine was quite small. The lower molar series is of the *Palæotherium* type, and the last lower molar has a well developed third lobe.

The vertebræ of *Tillotherium* resemble those of some carnivores. The cervicals are short, and the ends of the centra nearly flat. The dorsals are of moderate length, and also amphiplatyan. The lumbars are quite large. The humerus is stout, and broad transversely at the distal end, which has a supra-condylar foramen. The radius and ulna are separate, and of nearly equal size. The radius is short, and both ends are expanded transversely, indicating but little rotation. The scaphoid and lunar bones are distinct,* and the pisiform is large and stout. The feet were plantigrade. There were five digits in the manus, the first being well developed. The metacarpals are short, and the terminal phalanges long, compressed and pointed, somewhat similar to those in the Bears. (Plate IX, figure 3.) The femur is of moderate length, and its head has a pit for the round ligament. There is a well marked third trochanter. The distal end of the femur is compressed in a fore and aft direction. The tibia and fibula are distinct, and the latter is curved and slender. The calcaneum is elongate, and the astragalus, depressed, with only a slight superior groove. The hind feet were plantigrade, and the five digits were similar to those of the manus.

The remains of this genus at present known are from the Eocene of Wyoming. The specimens preserved indicate animals from one-half to two-thirds the size of a tapir.

Yale College, New Haven, Feb. 18, 1876.

*** The scaphoid and lunar bones have not yet been found united in any Eocene mammal.**

[To be continued.]

EXPLANATION OF PLATES.

Plate VIII—*Tillotherium fodiens* Marsh. Figure 1, side view of skull; figure 2, lower jaw, side view; figure 3, top view of skull. All one-half natural size.

Plate IX—Figure 1. *Tillotherium fodiens* Marsh. Front view of skull: One-half natural size; figure 2, bottom view of same skull, one-half natural size; figure 3, ungual phalanx of same specimen; *a*, front view; *b*, side view; natural size. Figure 4, last upper molar of *Tillotherium latidens* Marsh, natural size. Figure 5, lower molar of *Anchippodus minor* Marsh. (*Trogosus castoridens* Leidy) natural size.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XXXI.—*On the Gases contained in Meteorites;* by ARTHUR W. WRIGHT, Professor of Molecular Physics and Chemistry, in Yale College.

IN an article published by the writer in this Journal, for July, 1875, an account was given of an examination of the gases obtained from the meteorite of Iowa County, Iowa, which fell on February 12, 1875. This meteorite is of the ordinary stony kind, containing 12·54* per cent of nickeliferous iron, and the investigation was undertaken chiefly with a view to ascertain whether the spectrum of the gases evolved from such a body, by the application of heat, would afford any information respecting the recent theories connecting such meteorites with the comets. An analysis of the gases obtained at moderate temperatures developed the unexpected fact that their chief constituent was carbon dioxide, with a small proportion of carbonic oxide, these two gases constituting more than nine tenths of the product evolved at a temperature of 250°, and nearly one half of that given off when the heat was just below redness. As was to be expected from such a composition, the spectrum obtained from the earlier portions of gas given off was chiefly that of the carbon compounds, and showed a very close resemblance to those of several of the comets.

Among the conclusions drawn from the investigation, it was stated, that the nature of their gaseous contents establishes a marked distinction between the stony meteorites and the irons

* Analysis of Prof. J. L. Smith, this Journal, III, x, p. 362.

"hitherto examined," provided the Iowa meteorite could "be taken as a representative of its class."* With a view to obtain data for a more extended comparison, the investigation was continued, and a number of meteorites of both classes examined. The results of this work are given below, and it will be seen that they tend to justify completely the conclusions in my former paper, so far as any limited number of determinations could do so.

The method of experiment was the same as that described in the former paper, except in some of the minor details, and need be but briefly described here. The specimen to be examined was placed in a tube of very hard and refractory glass, which was merely softened at a red heat, and which, when filled with the meteoritic substance, could be maintained for a long time at this temperature without yielding more than so much as merely to deform the tube. In no instance was air admitted by the cracking or drawing in of the hot glass. The air was exhausted and the gas collected by means of a Sprengel pump of such perfection that it would produce a vacuum of but a fraction of a millimeter, and maintain it for days unchanged. The specimen tube having been attached to the pump, the latter was set in action and kept running until the air was thoroughly removed, as could be seen by the state of the gauge. The meteorite was then heated cautiously and the gas pumped out into the tube in which it was to be examined. Further details of the mode of procedure, where varied in the different cases, will be given in their appropriate places.

The problem of determining the exact nature and relative proportion of the gases in a meteorite is less simple than it might at first sight appear. For not only, as Grüner has shown,† is metallic iron attacked by carbon di-oxide, but it also, in the presence of this gas, or other oxidizing agents, determines the reduction of carbonic oxide, and its disappearance therefore from the gaseous products. In the case of the stony meteorites the question is still more complicated, as there is always present a greater or less quantity of oxide of iron, which at an elevated temperature must exert no inconsiderable influence upon the constitution of the gaseous mixture obtained from the mass. Grüner's very careful experiments showed that pure carbonic oxide progressively reduces the oxide of iron, at a temperature of 400° C. On the other hand it is itself reduced by metallic

* This conclusion has been criticized as hasty by Prof. J. W. Mallet (this Journal, III, x, 206), and a second one by M. M. Delafontaine, (Bibliothèque Universelle, Oct., 1875, 188), both of whom have overlooked or ignored the fact that they were given as merely provisional, conditioned upon the assumed general agreement of other iron and stony meteorites, as respects the gases derived from them, with those to which the statement referred.

† Comptes Rendus, lxxxiii, p. 28, et al., lxxiv, p. 231, etc.

iron, with a deposition of pulverulent carbon, though the action is very slight at temperatures less than 400° C. The commission who reported upon his memoir, in repeating some of his experiments, found that the temperature must exceed 350° in order that this effect may be produced at all. At higher temperatures the action is very marked. More recently Sir I. Lowthian Bell, in his work containing the results of a very elaborate and admirable series of researches upon the mutual action of the two oxides of carbon in the presence of metallic iron and oxide of iron,* has, in the main, confirmed Grüner's conclusions, but has shown that the results vary, not only with the temperatures, but also with the relative proportion of these substances present. He found that pure carbonic oxide begins to reduce Fe_2O_3 at from 140° to 200° C., according to the substance used, while at a moderate red heat the oxygen is rapidly removed, with the formation of carbon di-oxide. On the other hand the latter gas was partially reduced by spongy iron at a low red heat, with the formation of carbonic oxide. We have further to consider the action of the hygroscopic moisture upon the metallic iron, as well as the mutual action of hydrogen and oxide of iron, at elevated temperatures.

It is very evident then that the composition of the gases obtained at or above the temperature of red heat cannot be considered to represent accurately the true constitution of the gaseous contents of a meteorite, and especially is this true in the case of the stony ones. On the other hand we can hardly assert with confidence that the different gases are expelled in exactly their proportionate amounts at all temperatures. In fact the experiments show that the proportions of the gases vary with the temperatures of their evolution in a manner not satisfactorily explainable on the assumption that such an effect is due to chemical action alone. It is important therefore that the experiments should be conducted in such a way as to facilitate as much as possible the evolution of the gases, while at the same time they are exposed for as short time as possible to the action of high temperatures. The first of these conditions is attained in a good degree by reducing the material examined to a state of minute subdivision. The second is approximated by continuing the application of the high temperatures for the shortest time consistent with a satisfactory effect in driving off the gases sought.

In the case of the iron meteorites the material was generally prepared by boring out the solid iron with a steel drill upon a lathe, the substance being rendered as fine as possible. In

* Chemical Phenomena of Iron Smelting.

some instances this was not practicable from deficiency of material, and chips produced by a planing machine were used. The stony meteorites were reduced to powder in a diamond mortar. The iron contained in them being for the most part in very minute particles no further operation was necessary in this case. The powder from the irons, when the tube containing it was deprived of air, gave off a small quantity of gas from the mere diminution of pressure, without the application of heat, in one instance enough having been evolved to allow of its collection in a tube. A qualitative examination of it showed that hydrogen and the oxides of carbon were present, leaving no doubt that the mere pulverization of the iron was sufficient to cause it to part with a portion of its gaseous contents at ordinary temperatures, and greatly to facilitate the process at higher temperatures.

The heat was applied by means of a Bunsen burner, carried slowly back and forth beneath the tube, which was wrapped with wire gauze. For the irons the temperature was carried, in the first instance, to a point below redness, in order that the action of the iron upon the gases should be as little as possible. It was about 500° C. The gauge was watched during the heating and, as soon as it ceased to rise perceptibly, the flame was slowly withdrawn, and the gas at once pumped out. The evolution of gas, at this temperature, generally ceased very nearly in twenty or thirty minutes. After the gas was thoroughly removed, the iron was heated to redness with a cluster of four Bunsen burners, the heat being continued as long as any considerable amount of gas appeared to come away. This required usually but thirty or forty minutes, though in one or two instances it was continued somewhat longer. It will be seen from the results given below that the larger portion of the gas was obtained at the lowest temperature, in every instance but one.

The iron meteorites examined were the following: First, that from Tazewell Co., Tennessee, described by Professor J. L. Smith, in this Journal, II, xix, 153. Its composition is Fe, 83·02; Ni, 14·62; other substances, 1·93. No carbon was found. Specific gravity 7·9.

Second, that of Shingle Springs, Eldorado Co., California, described by Professor B. Silliman, this Journal, III, vi, 1. It contains Fe, 81·48; Ni, 17·17; C, 0·07, other substances, 1·27. Sp. gr. 7·875.

Third, the meteorite of Arva, in Hungary, noticed in this Journal, II, viii, 439. The analysis of A. Löwe gives Fe, 90·471; Ni, 7·321; residuum of carbon, silica, and cobalt, 1·404. Sp. gr. 7·814. Another analysis by Bergemann, Pogg. Ann., c. 256, gives for its composition, exclusive of the sulphide of iron contained in it, Fe, 82·25; Ni, 8·12; Co, 0·364; P, 0·74; C, 1·54; Graphite, 2·00.

Fourth, the great Texas meteorite in the cabinet of Yale College, described by Professor C. U. Shepard, this Journal, I, xvi, 216, also, with an analysis, by Professors B. Silliman, and T. Sterry Hunt, this Journal II, ii, 370. It contains Fe, 90·91; Ni, 8·46; residue containing carbon, 0·50. Sp. gr. 7·543.

Fifth, that from Dickson Co., Tennessee, described by Professor J. L. Smith, this Journal, III, x, 349, and examined at his request. It contained Fe, 91·15; Ni, 8·01; Co, 0·72; Cu, 0·06. Sp. gr. 7·717.

The following table gives the results obtained, the numbers expressing parts in one hundred. The numbers in the third line in each case give the percentage of each gas in the total amount obtained. They are not the simple averages of the numbers above them, but the means reduced according to the volumes in each case. The totals in the last column are the sums of the volumes given off at the different temperatures.

Name.	Temperature.	CO_2.	CO.	H.	N.	Volumes.
Tazewell Co.,	500°,	18·34	38·45	41·51	1·70	1·87
	Red heat,	7·76	45·75	44·76	1·73	1·30
	Total,	14·40	41·23	42·66	1·71	3·17
Shingle Springs,	500°,	19·98	13·52	60·92	5·58	0·65
	Red heat,	1·10	10·39	84·40	4·11	0·32
	Total,	13·64	12·47	68·81	5·08	0·97
Arva,	500°,	18·20	38·72	40·62	2·46	8·89
	Red heat,	11·25	74·59	12·84	1·32	38·24
	Total,	12·56	67·71	18·19	1·54	47·13
Texas,	500°,	9·76	8·43	81·81	....	1·10
	Red heat,	2·18	48·58	49·24	....	0·19
	Total,	8·59	14·62	76·79	....	1·29
Dickson Co.,	Total,	13·30	15·30	71·40	....	2·2

The small quantity of the iron available in the examination of the Dickson Co. meteorite rendered it necessary to be content with a single heating to redness. The iron was in the form of coarse chips which were cut by a planing tool. The same was true of the Shingle Springs iron, and this accounts in part for the smaller volume of gases obtained in these two cases.

We may add to this list the Lenarto iron examined by Professor Graham,* and the meteorite of Augusta Co., Virginia, the gases from which were analyzed by Professor J. W. Mallet.† The former yielded CO, 4·46; H, 85·68; N, 9·86, the whole amount of gas being 2·85 times the volume of the iron. The

* Proc. Royal Soc., xv, 502. † Ibid., xx, 365.

latter gave CO_2, 9·75: CO, 38·33; H, 35·83; N, 16·09, and 3·17 volumes of gas in all. In both these instances the iron was very strongly heated, the temperature in the latter case being carried nearly to whiteness, and continued for several hours. The volume of gas was divided into three parts, and the portions obtained at the beginning. middle, and end of the operation separately analyzed. Reducing the volumes given by Professor Mallet for each of the gases in these portions to parts in one hundred, we have the following numbers:

	CO_2.	CO.	H.	N.
Beginning,	15·09	30·74	42·52	11·65
Middle,	4·23	46·12	43·64	6·01
End,	3·69	47·00	13·36	35·95

The percentages in the total amount of gas obtained are given above. It will be seen that the results for the first two portions closely resemble those given for the Tennessee iron in the table.

In the experiments with meteorites of the stony class the same method, in general, was pursued, except that the first temperature was somewhat lower, being about 350°. This was adopted in order to lessen as much as possible the chemical action of the substances upon each other, and at the same time because the relative proportions of the amounts of gas obtained at this and the higher temperature were more convenient for the analyses.

The meteorites examined were the following: First, that from Guernsey Co., Ohio, which fell on May 1, 1860, and is described by Professor J. L. Smith, in this Journal, II, xxxi, 87. It contains 10·7 per cent of nickeliferous iron, and has a specific gravity of 3·55.

Second, one from Pultusk, in Poland, which fell on January 30, 1868. This was subjected to an elaborate investigation, and described, by Dr. G. vom Rath.* Several thousand small masses were collected, of which, some examined by vom Rath were found to contain 10·06 per cent of nickeliferous iron, though other specimens analyzed by Werther and Rammelsberg gave 21·08, and 21·78 per cent respectively.† It resembles somewhat the Iowa stone in its general character, and has a specific gravity of 3·725. The writer is indebted to the courtesy of Professor G. J. Brush, who sacrificed an excellent specimen for the examination, from his private cabinet.

Third, the meteorite of Parnallee, India, Feb. 28, 1857, found by Pfeiffer‡ to contain 6·84 per cent of meteoric iron. It has a specific gravity of 3·44.

* Festschrift der Niederrheinischen Gesellschaft für Natur- und Heilkunde zum 50jährigen Jubiläum der Universität Bonn.

† C. Rammelsberg, Die chemische Natur der Meteoriten. Abhandlungen der Königl. Akad. der Wissenschaften zu Berlin, 1870.

‡ Wien. Akad. Ber. 47.

Fourth, the meteorite of Weston, Conn., which fell Dec. 14, 1807. This is one of the most interesting meteorites known, and is remarkable both for its lithological character, and for the large amount of iron contained in it, this being estimated as from 30 to 40 per cent. Its specific gravity is 3·6.* These, together with the Iowa County meteorite, all belong to the class of chrondrites, of G. Rose, or sporadosidères, of Daubrée, and are good representatives of the ordinary or most numerous class of the stony meteorites.

In the examination of the Iowa County meteorite already referred to, the determinations were made for a number of different temperatures, the results being as follows:

	At 100°.	At 250°.	Below red heat.	At low red heat.	At full red heat.
CO_2	95·46	92·32	42·27	35·82	5·56
CO	0·00?	1·82	5·11	0·49	0·00
H	4·54	5·86	48·06	58·51	87·53
N	0·00	0·00	4·56	5·18	6·01
	100·00	100·00	100·00	100·00	100·00

The separation of the gaseous volume into so many small portions rendered the estimation of minute quantities of any constituent less certain, and it is probable that the percentage of the nitrogen, which was estimated as a residue, may have had thus set down to it, besides the errors of the determinations, very small amounts of carbonic oxide and possibly of marsh gas, which was found in all the cases in the present investigation. But they were at all events too small to be certainly distinguished from errors of observation. In the re-examination of this meteorite for carbon di-oxide mentioned below, the nitrogen was directly determined in gas given off after exposure to a red heat for a considerable time, and corresponding nearly to the portion referred to in the last column of the above table. The amount found was 3·41 per cent. But no great stress should be laid upon such a discrepancy, considering the manner and the purpose of the preceding determination. The latter determination agreed with the former as to the absence of carbonic oxide and marsh gas, at that temperature.

The results obtained for the different cases are shown in the following table. The numbers given for the Iowa County meteorite are reduced from the former analysis, the volumes being obtained from the notes made at the time, and 500° being assumed as approximately representing the temperature there given as "below red heat." The first temperature in the case of the Ohio meteorite was also 500°, this being the first one determined. The second heating was also continued for a longer time, which accounts for a slight difference between this

* B. Silliman, Sen., Memoirs Conn. Acad., vol. i, p. 142.

and the other cases. As it was found that this degree of heating left too small a proportion of the gas for the second determination, as also for other reasons mentioned above, the temperature of about 350° was employed in the succeeding experiments:

Name.	Temperature.	CO_2.	CO.	CH_4.	H.	N.	Volumes.
Ohio,	500°,	82·28	2·16	2·26	12·37	0·93	2·06
	Red heat,	16·79	8·71	1·66	69·43	3·41	0·93
	Total,	59·88	4·40	2·05	31·89	1·78	2·99
Pultusk,	350°,	81·01	1·99	1·73	13·36	1·91	0·99
	Red heat,	33·97	7·35	6·00	49·99	2·69	0·76
	Total,	60·29	4·35	3·61	29·50	2·25	1·75
Parnallee,	350°,	87·53	1·13	1·22	8·72	1·40	1·56
	Red heat,	72·43	2·53	3·22	20·03	1·79	1·17
	Total,	81·02	1·74	2·08	13·59	1·57	2·63
Weston,	350°,	86·29	1·84	1·19	8·59	2·09	2·69
	Red heat,	62·18	3·43	3·10	28·16	3·13	0·80
	Total,	80·78	2·20	1·63	13·06	2·33	3·49
Iowa,	500°,	58·04	4·01	0·0	34·82	3·13	1·04
	Red heat,	19·16	0·21	0·0	74·49	6·14	1·46
	Total,	35·44	1·80	0·0	57·88	4·88	2·5

The heat was continued, in the case of the Iowa meteorite, longer than in the subsequent experiments with the others, and the result shows a greater diminution in the amount of carbon di-oxide obtained. Rejecting the last column in the analysis quoted above, we have for the total average percentage up to red heat, CO_2, 49·51; CO, 2·64; H, 43·93; N, 3·92, which corresponds more nearly with the results in the other cases. The numbers given in this table show a very satisfactory concordance, though there are slight differences, doubtless arising from the fact that the temperatures employed, and the times of exposure to the heat, though approximately the same in the different instances, could not be made absolutely identical. The mass of material operated upon was also not always the same, which would produce a slight difference in the time required for the evolution of the gas, and the completeness of its elimination.

It will be observed that a small amount of marsh gas was found in each of the portions of gas obtained in the present investigation. This might possibly be accounted for, in the case of the higher temperatures, by the decomposition of organic matter taken up by the meteorite subsequently to its fall, or of carbonaceous matter originally contained in it; but as such decomposition would not be likely to take place, to any great extent, at so low a tempera-

ture as 350°, there is reason for believing that it is really one of the constituents of the meteoritic gases. The determinations made both by absorption of the carbonic oxide with cuprous chloride, and by the production of carbon di-oxide after the explosion with oxygen, agreed very well, and the analyses in each case were best satisfied by the assumption of the amounts of marsh gas indicated in the table. The Ohio meteorite was also examined at a number of different temperatures, the different portions of gas having the following proportions of carbon di-oxide: at 100°, 95·92; at 250°, 86·36; at 500°, 82·28; at incipient red heat, 33·55; at red heat, 19·16, showing a progressive decrease similar to that observed in the case of the Iowa meteorite.

On comparing the results given in the two tables a marked difference is at once evident. Not only do the stony meteorites give off a much larger volume of gas at low temperatures, but the composition of it is in all the cases examined quite distinct from that of the gas evolved from the irons. In no case among the results obtained from the latter is the amount of carbon di-oxide greater than 20 per cent at 500°, nor than 15 per cent from the whole quantity evolved, while in every case but one the volume of carbonic oxide is considerably larger. In the chondrites, on the other hand, the percentage of the latter gas is conspicuously small, while the carbon di-oxide is more than half of the total quantity of gas obtained up to red heat, except in the case of the Iowa meteorite, and in that the percentage is not much less, especially if we reject the numbers in the last column above, for the amount obtained by a second and long-continued application of red heat. At a temperature of about 350°, it constitutes from 80 to 90 per cent of the gaseous products, in all cases, while at the heat of 100° C. it forms somewhat more than 95 per cent of the gas evolved in the only two cases examined in this respect. The hydrogen, on the other hand, progressively increases in quantity with the rise in the temperature of evolution, and in the last portions given off at red heat is generally the most important constituent. Its proportion in the total percentage would, no doubt, be considerably increased if the heat were greatly intensified, as for instance, if carried to a point approaching whiteness, but the results obtained in such a way would be entirely unreliable, from the action of the metallic iron and the oxide of iron on the carbon compounds, or upon the hydrogen itself.

In the examination of the Parnallee, Pultusk and Weston meteorites, a small quantity of the moisture given off at a high temperature was collected in a glass tube attached to the pump and surrounded with a freezing mixture. This, when tested, gave distinct traces of chlorine for the Parnallee and Weston,

but that from the Pultusk seemed to contain little or none. The latter however, as well as the Parnallee, showed the presence of a minute quantity of sulphurous oxide, the Weston meteorite less certainly.

A question naturally suggests itself as to the manner of the occurrence of the carbon di-oxide in conditions which admit of its being separated so much more readily than the other gaseous substances. The most probable supposition seems to be that it is condensed upon the fine particles of iron as well as absorbed within them. That it is produced by the decomposition of some carbonate is not likely to be the case, since the carbonates that could occur in meteorites all require high temperatures for the evolution of this gas, and the quantities obtained should increase constantly with an increase of temperature, whereas the reverse is true; and certainly none of them would give up the gas at the temperature of boiling water. Another hypothesis might be that it is absorbed in part from the atmosphere. To test this, a re-examination of the Iowa meteorite was made, the material being heated until it yielded as nearly as possible the same volume of gas as in the experiments of the preceding year, a short time after its fall. Had it been constantly gaining carbon di-oxide from the air it should have given the same amount of gas as before at a lower temperature. On the contrary it required a more intense heating, and a longer continuance of the process. The percentage of CO_2 was found to be 32·65. If any difference exists therefore it has lost rather than gained, at least in this interval of nearly a year. It is very probable therefore that no considerable part of the gas is derived from the atmosphere, though this cannot be asserted absolutely, and the question must remain for further investigation. The portions of gas from each of the stony meteorites, except the Pultusk, which was not examined, gave cometary spectra, similar to that from the Iowa specimen.

On reviewing the results of the investigation there appears no reason for modifying the conclusions arrived at in the former article. The evolution of such volumes of carbon dioxide may well be taken as a characteristic of the stony meteorites, and its relation to the theory of comets and their trains is certainly of great significance. The further discussion of some of the results of the investigation, and certain interesting questions suggested by them, are reserved for another communication.

Yale College, March 18, 1876.

ART. XXXII.—*Review of Croll's Climate and Time with especial reference to the Physical Theories of Climate maintained therein;** by SIMON NEWCOMB.

THE present notice of Mr. Croll's work is confined to an examination of his physical theories of climate, avoiding all those portions which have a geological bearing. The physical theories propounded have two distinct applications; the one to the present climate of the earth; the other to the changes of that climate during past geological ages. In the latter department of the work the principal object is to account for the glacial epoch or epochs, the author conceiving that there may have been several such epochs. The data from which his conclusions respecting the past are derived are necessarily founded on his theories of the causes of present climate, since it is only by a thorough discussion of the way in which all climatic causes operate, and by tests of all the conclusions by a comparison with the present climate of the globe, that any safe rules can be formed for judging of the climate of the past.

We are forced to say at the outset that the physical data for forming a reliable estimate of the separate effects of various causes on climate are almost entirely wanting. The physical theory of cosmical heat is, at the present time, in a state nearly approaching the chaotic, a circumstance all the more surprising when we consider the advanced state of other departments of the theory of heat. Cournot and his successors have devoted to the mechanical theory of heat an amount of profound research which has made it a branch of the most exact of the sciences. On the other side, Melloni and his successors have done a great deal for what we may call the chemical theory of heat. Between these two lie the physical theory, as affecting climate and cosmical temperature, which has, comparatively speaking, been neglected entirely. To illustrate what we mean let us consider the temperature of the earth from the widest point of view. Practically, there is but one source from which the surface of the earth receives heat, the sun, since the quantity received from all other sources is quite insignificant in comparison. There is but one way of losing heat, by radiation into space. The temperature of the surface being in a state of permanent equilibrium, the quantity of heat radiated and reflected must be equal to the total quantity received from the sun. It is this equality which determines the mean temperature of the surface of the globe.

If the earth were not surrounded by an atmosphere, if, consequently, the amount of heat radiated from each square foot of the land, as well as from the whole surface, were equal to that

* Climate and Time in their geological relations: a theory of secular changes of the Earth's Climate. By James Croll. New York, D. Appleton & Co., 1875.

received from the sun, the problem of climate would be a quite simple one. But the atmosphere, and especially the vapors suspended in the atmosphere, exert a powerful influence in various ways. Perhaps the most general and wide-spread source of this influence may be found in the probable unequal diathermacy of the atmosphere to solar and terrestrial heat which may result in the mean temperature being higher than it would be if there were no atmosphere. To investigate this influence the first datum necessary is the mean temperature, first of the whole earth and then of its various zones, which would be maintained if there were no atmosphere. In other words, we wish to know what would be the temperature of a small solid body revolving round the sun at the mean distance of the earth, and presenting all its sides equally to the sun in rapid succession. *This temperature may be called the normal temperature of the region in which the earth is moving.*

We repeat that the foundation stone of any reliable investigation of terrestrial climate, with respect to its causes, must be a knowledge of this normal temperature. Without it we may have any quantity of material for discussion but nothing on which we can base a theory worthy of the slightest confidence. There are of course many other questions to follow it, but this is the one which the investigator of this subject meets at the very threshold of his investigation, just as the surveyor who attempts to make a geodetic measurement first meets with the question of the length of his measuring rod. Now, no stronger example of the chaotic state of the theory of cosmical heat can be given than the simple fact that not only is this normal temperature entirely unknown, but, so far as we are aware, no attempt has ever been made to determine it. What adds to our surprise is that while no one has attempted to determine what temperature a body like the earth would acquire in free space exposed to the solar rays, there have been a number of attempts to answer the experimentally impossible question what temperature such a body would acquire if the solar heat were cut off, so that the body should be exposed to stellar radiation alone, a temperature known in our books as that of space.

In justice to physicists it must be said that one step toward determining this fundamental temperature was taken many years ago. Pouillet and Herschel determined the actual quantity of heat radiated by the sun, and their results have been of the greatest value in investigating the thermal relations of the solar system. The remaining part of the problem is more laborious, but not, we conceive, more difficult.

Since Mr. Croll had not at hand the means of commencing a complete investigation of the causes on which terrestrial climate depends, his theory must, of necessity, fail to be entirely conclusive. Still it is worked out in a manner so laborious as to

render it worthy of very careful consideration, although, owing to the diffuse mode of treatment adopted, the complete mastery of his views is a very difficult task. For this reason it is not easy for the reviewer to feel sure that he is giving such a statement of the author's views as the author himself would regard as entirely satisfactory. We may say, however, in brief, that one great object of the author is to insist upon the important agencies played by ocean currents in influencing climate. Indeed, beyond the regular astronomical variation of climate with the latitude, this seems to be the only influence which he will allow to be important. The influence of the Gulf Stream in modifying the climate of Northeastern Europe receives especial attention, and his views of this influence seem quite well grounded. We had supposed the view that the warm and equable climate of that region was due to the Gulf Stream to be one universally held, although no one had attempted to render it plausible by an actual calculation of the amount of heat conveyed by that stream. This calculation Mr. Croll has made, and having reduced his own estimate of the volume of the stream to one-half, in deference to the views of some of his opponents, he shows that the amount of heat annually conveyed away by the stream is equal to the whole amount which a belt of the earth sixty-four miles broad, extending all round the equator, receives from the sun. We make the quantity a little less, but yet equivalent to more than the total amount of heat which falls on a million of square miles at the equator. Making all allowance for the uncertainties of these data, and for the fact that only one of the two branches of the Gulf Stream passes over to Northeastern Europe, it must yet be admitted that the quantity of heat which that region receives from the Gulf Stream is not an inconsiderable fraction of that which it receives from the sun.

An essential part of Mr. Croll's system is the wind theory of oceanic circulation, essential, however, to his views of the climate of the glacial period rather than to the climate of the present. This is a point on which there is some difference between Mr. Croll and his numerous opponents, especially Dr. Carpenter. Having made no examination of the views of Dr. Carpenter, we cannot pronounce them wrong, but the view maintained by Mr. Croll, that the winds are the principal causes of ocean currents seems well sustained. The direction of these currents may be materially modified by the earth's rotation, a cause which can be investigated only by mathematical methods, and until the mode of operation of this cause is fully understood, we cannot feel sure that the theory is complete. So far as we are aware Mr. Ferrel is the only mathematician who has entered upon this investigation, but Mr. Croll does not seem to have made much use of his results. The principal

support of the wind theory is found in the very obvious general correspondence between the winds and currents of the ocean, a correspondence so striking that it is difficult to see how the strongest presumption of a causal connection can be avoided. That the winds are, in a general way, amply sufficient to produce regular currents in the ocean seems to be shown by a familiar phenomenon on our Eastern coast. It is well known that the tides are there materially modified by the winds, so that the time of high water may be delayed or accelerated by an entire hour or more, and the height changed by one or more feet in consequence of a heavy wind. The effect of a wind thus determined must be the same as that of a difference of level equal to that which the wind is found to produce, and this again must be sufficient to produce a very strong surface current. Moreover, a continuous surface current must, in time, extend itself to a great depth through friction.

In thus sustaining the wind theory, we must not be understood to deny the existence of a general law of oceanic circulation which we understand to be due to Dr. Carpenter, and by which an undercurrent of cold water runs from each pole to the equator, to return as a surface current of warm water. That the mass of ice-cold water which forms the depths of the ocean came from the poles, and that to keep it cold, the supply must be constantly though slowly renewed will, we conceive, be disputed by no one. And the renewal of the water necessarily implies a surface set from the equator toward the poles. But, when we inquire whether the quantity of water thus interchanged can be so great as to give rise to the observed ocean currents, the answer is not quite clear, and the probabilities seem to incline to the negative. At the same time, we may have here an important feature among the causes which produce ocean currents, and the scientific method of investigating the subject is not by mere arguments, but by actual calculating the effect of each cause with judicial impartiality. Perhaps it would be unfair to say that Mr. Croll does not attempt to do this, but the impression left on the mind of the reader is that the "gravitation theory" of oceanic circulation is examined rather to refute it than to determine with mathematical precision what part differences of gravity between the polar and equatorial waters do really play in the phenomena in question.

While we agree with Mr. Croll in the important part he assigns to oceanic currents in modifying climate, we cannot accept the reasoning by which he attempts to prove that the corresponding influence of aerial currents is entirely insignificant. Speaking of the possible amount of heat conveyed by the upper currents, or anti-trades, from the equatorial to the polar regions, he says:

"The heated air rising off the hot burning ground of the equator, after ascending a few miles, becomes exposed to the intense cold of the upper regions of the atmosphere; it then very soon loses all its heat and returns from the equator much colder than it went thither." * * * "During all this time [while the upper current is traveling from the equator toward the poles] the air is in a region below the freezing point; and it is perfectly obvious that by the time it begins to descend it must have acquired the temperature of the region in which it has been traveling."

This passage is quoted as showing the weakness which everywhere marks Mr. Croll's reasoning on the subject of temperature. With all the care and study he has devoted to the subject, we are entirely unable to reconcile his views with the known laws of heat. The facts that the same amount of heat is given off when water freezes or vapor condenses which is necessary to melt the ice or to evaporate the water; that the amount of heat developed by the compression of air is equal to that absorbed by its expansion; that if, from any cause, heat passes very slowly from a warm body A to a cool body B, it will also pass slowly from B to A when B is the warmer; that a body cannot abstract heat from another without itself becoming warmed, belong to a class which he does not seem to bear in mind. In the passage we have quoted, he speaks of the hot air rising from the earth and becoming exposed to the intense cold of the upper regions of the atmosphere. But, what can this cold be but the coldness of the very air itself which has been rising up? If the warm air rises up into the cold air, and becomes cooled by contact with the latter, the latter must become warm by the very heat which the former loses, and if there is a continuous rising current, the whole region must take the natural temperature of the rising air. This temperature is indeed much below that which maintains at the surface, for the simple reason that air becomes cold by expansion according to a definite and well known law.

Having thus got his rising current constantly cooled off by contact with the cold air of the upper regions, it has to pass on its journey toward the poles "in a region below the freezing point." Here again the question arises whether Mr. Croll conceives that the temperature of a region can be anything materially different from the temperature of the air or other substance which fills the region. Apparently he does, for he speaks of the air "acquiring the temperature of the region," but what the difference is, or can be, he does not explain. There is such a thing as temperature expressive of the amount of radiant heat passing through a diathermanous region, but the "upper regions" are exposed to the radiation of the sun on the one side, and of the earth's lower atmosphere on the other,

and there is no proof that these do not equal the surface temperature. Having thus cooled off his upper current still farther by its passage through this "cold region," and that without the region becoming any warmer, he leaves it to find its way to the earth's surface, entirely oblivious of the fact that an amount of heat will be evolved by compression in the polar regions, or whereever the current reaches the earth again, fully equal to that which it lost when it rose from the equator. If he had treated this aërial current precisely as he did the Gulf Stream, computed the probable amount of the current, its temperature when it rose from the earth in the tropics, and again when it reached the earth in northern regions, and thus determined the amount of heat given out during its passage, his course would have been much more logical.

We do not propose to enter into the question of fact, how much of an upper current there really is passing from the tropics to the poles. But, if it is as great as is commonly supposed, it must be as powerful as ocean currents in tending to equalize the temperature of the globe. The fact that it is cold during its passage, instead of being a disadvantage, is a positive advantage, because the heat which it carries being latent in form is not liable to be dissipated by radiation.

Another proposition which the author attempts to prove, by reasoning which seems equally inconclusive, is, that the mean temperature of the ocean is greater than that of the land over the entire globe. We may examine his argument, for the reason that the proposition is a fundamental one in his theories of climate. The most natural and conclusive way of establishing such a proposition, would be by actual observations of temperature, but no attempt to do this is made. The author rests his doctrine wholly on four *a priori* reasons, which we may consider in their order.

(1.) "The ground stores up heat only by the slow process of conduction, whereas water, by the mobility of its particles, and its transparency for heat rays, especially those from the sun, becomes heated to a considerable depth rapidly. The quantity of heat stored up in the ground is thus comparatively small, while the quantity stored up in the ocean is great." We can hardly stop to criticise these sentences, implying as they do, that the rapidity with which solar heat is absorbed by a body determines its temperature, and also depends on its diathermancy, and that a body which is heated only by the slow process of conduction must be permanently colder than one into which the radiant heat of the sun can penetrate.

(2.) "The air is probably heated more rapidly by contact with the ground than with the ocean; but on the other hand it is heated far more rapidly by radiation from the ocean than from the land. The aqueous vapor of the air is to a great ex-

tent diathermanous to radiation from the ground, while it absorbs the rays from water and thus becomes heated." According to the usually received laws of heat, one body can be heated from another only when the latter is the warmer of the two, and the rapidity with which the heating process goes on depends on the difference of temperature, no matter whether the heat passes by conduction, or by radiation. If, then, the air is really heated by contact with the ground more rapidly than by contact with the ocean, it can only be because the ground is hotter than the ocean, which is directly contrary to the theory Mr. Croll is maintaining. The statement that the aqueous vapor of the air is diathermanous to radiation from land, but not to that from water, is quite new to us, and very surprising; but if it be true, Mr. Croll assigns directly contrary effects to the same cause in (1) and (2). Reasoning as in (1), he would have said that the air over the land, owing to its transparency for the heat rays from the land, becomes heated to a great height rapidly, while the air over the ocean, not being transparent, can acquire heat from the ocean only by the slow process of convection.

(3.) "The air radiates back a considerable portion of its heat, and the ocean absorbs this radiation from the air more readily than the ground does." Here we have the air giving back to the ocean the same heat which it absorbs from it, and thus heating it. Apparently, Mr. Croll thinks that air and ocean can thus alternately heat each other up to an indefinite extent, by natural radiation, without any necessity for more than a mere nest-egg of heat to start with from any outside source. (4) seems to be little more than a repetition of (2) in a different form.

Another idea of the author which calls for explanation is that solar heat absorbed by the atmosphere is entirely lost, so far as warming any region of the globe is concerned. For instance, in comparing the relative amount of heat received from the sun by the equatorial and the arctic regions, he thinks it a mistake not to allow for the fact that a greater percentage of the heat is absorbed by the atmosphere in the polar regions than at the equator. From the care he takes to subtract this percentage from the amount of heat received by the polar regions, he seems to think that the heat thus absorbed is totally lost, and does not warm the atmosphere at all. But a moment's reflection must show that as all this absorption must occur within three or four miles of the earth's surface, and probably half of it within a single mile, or two miles at most, while the arctic regions are more than 2,000 miles in diameter, it makes no difference what portion of the heat is absorbed by the atmosphere. In the one case, the atmosphere is warmed directly by

the absorption of heat, in the other, by contact with the earth; but the temperature of the region is substantially the same in either case.

We may now pass to the consideration of the author's views of the cause of the Glacial epoch, or of glacial epochs in general, as, according to his view, there must have been several of them. He maintains that such a phenomenon may be fully accounted for by the great eccentricity which the orbit of the earth is known to assume at certain very long intervals. Using Le Verrier's formulæ for the secular variation of the planetary orbits, he has computed this eccentricity for a number of periods, extending back nearly 3,000,000 years, and has thus found a number of epochs at which it was three or four times as great as at present. That, in the course of each million of years, there are from time to time such periods of great eccentricity is a well established result of the mutual gravitation of the planets, but whether the particular epochs of great and small eccentricity computed by Mr. Croll are reliable is a different question. The data for this computation are the formulæ of Le Verrier, worked out about 1845, without any correction either for the later corrections to the masses of the planets, or for the terms of the third order subsequently discussed by Le Verrier himself. The probable magnitude of these corrections is such that reliance cannot be placed upon the values of the eccentricity computed without reference to them for epochs distant by nearly a million of years. This fact, of itself, does not militate against Mr. Croll's theory, since the correct formulæ would no doubt show other epochs of great eccentricity which would entirely satisfy his conditions. The proposition with which we are more especially concerned is the general one that a great eccentricity, with the perihelion in one of the solstices, will give rise to a glacial epoch in the hemisphere corresponding to that solstice, and it is the reasoning by which Mr. Croll endeavors to sustain this proposition which we next propose to examine.

The difficulty which the sustainer of this proposition encounters at the outset is the demonstration of D'Alembert that, whatever changes the earth's eccentricity and perihelion may undergo, the total amount of heat received from the sun in the course of a year is still the same for each hemisphere. Consequently, if the mean temperature of the hemisphere depends on the total amount of heat received, it must be the same for the two hemispheres, and but slightly different from the mean temperature of the present time. To understand the question clearly let us suppose the perihelion to coincide with the June solstice, so that the earth is nearest the sun in our northern summer, and farthest from it in our northern winter. Then, in this

hemisphere, considering only the heat of the sun, we shall have a short and hot summer, and a long and cold winter, while in the southern hemisphere the summer would occur when the sun was farthest off, and the winter when he was nearest, so that the rigor of both seasons would be greatly mitigated. Still, as just stated, the mean temperature due to solar heat would be the same in each hemisphere, the northern hemisphere having the hotter summer as well as the colder winter.

While admitting this equality in the total amount of heat received from the sun, Mr. Croll endeavors to show that the northern hemisphere would be colder and that there would be an accumulation of snow and ice during the long winter which would not be melted by the sun's rays during the short and hot summer. His principal arguments in favor of this view are given in Chapters II and IV. Beginning with the winter he says that the reduction in the amount of heat received from the sun during this season, owing to his greater distance, would lower the mid-winter temperature to an "enormous extent." Precisely how great a diminution of temperature he considers enormous he does not state in this connection, but in a subsequent chapter he computes a diminution in the mid-winter temperature of Great Britain sometimes amounting to more than 30° from this cause. This computation we regard as entirely untrustworthy, being founded on purely hypothetical laws with purely hypothetical data, but we need not challenge the result at present. The effect of this lowering of the temperature would be, he says, a great increase in the amount of snow which would fall during the winter. This conclusion we cannot accept. During the long cold winter the evaporation must be lessened, and hence the amount of precipitation also, unless warm and moist air is brought from the warmer regions of the globe. In this case the latent heat set free by precipitation, as well as the heat of the air itself, would mitigate the winter temperature. On the whole, we may consider the equivalent of twenty inches of solid ice to represent a very liberal estimate of the probable average amount of snow which would accumulate over any very great extent of surface during any one winter.

Mr. Croll's next point is that the presence of so much snow would lower the summer temperature, and prevent to a great extent the melting of the snow. He gives three reasons for this extraordinary proposition. In the first place the air will be cooled by radiation to the snow more rapidly than it will be heated by the sun. Of the fact that this cooling of the air would itself be necessarily accompanied by a melting of the snow he shows no consciousness. A simple calculation will show that a cooling of the air by some 30° Fahrenheit would melt the whole twenty inches of snow.

The second reason is that the rays which fall on snow and ice are to a great extent reflected back into space, the grounds of this statement being apparently the transparency of the atmosphere to the calorific rays of the sun on which he had just been insisting, and which he must have had in mind as explaining how the reflected rays can be got back into space. How great the reflecting and transmitting power of the snow and ice must be, to keep the snow unmelted all summer, may be inferred from the fact that during this perihelion summer the amount of heat received from the sun by every part of the northern hemisphere would suffice to melt from four to six inches of ice per day, over its entire surface, that is, it would suffice to melt the whole probable accumulation in three or four days. The reader can easily make a computation of the incredible reflecting power of the snow and of the unexampled transparency of the air required to keep the snow unmelted for three or four months.

The third cause of non-melting of the snow during summer is that snow and ice chill the air and condense the vapor into thick fogs which "would effectually prevent the sun's rays from reaching the earth, and the snow in consequence would remain unmelted during the entire summer." Here again, he says nothing about the latent heat set free by the condensation, nor does he say where the heat goes to which the air must lose in order to be chilled. The task of arguing with a disputant who in one breath maintains that the transparency of the air is such that the rays reflected from the snow pass freely into space, and in the next breath that thick fogs effectually prevent the rays ever reaching the snow at all, is not free from embarrassment. We can accept calmly any and every possible hypothesis respecting the properties and nature of the atmosphere which he chooses to propound, but must insist that the conclusions be drawn in accordance with the first principles of the theory of heat. We might therefore show that if the snow, air, fog, or whatever throws back the rays of the sun into space is so excellent a reflector of heat, it is a correspondingly poor radiator, and the same fog which will not be dissipated by the summer heat will not be affected by the winter's cold, and will therefore serve as a screen to prevent the radiation of heat from the earth during the winter.

Perhaps the shortest way of meeting the case is to refer to the best known facts of our own climate. Every winter a large portion of the northern hemisphere is covered with snow precisely as Mr. Croll supposes was the case during the Glacial epoch. According to his theory this accumulation of snow ought to offer a great resistance to the melting power of the sun's rays. How much resistance it does offer everyone knows. What effect the difference of astronomical conditions during

the epochs of great eccentricity might have had may be inferred from the fact that, adopting Mr. Croll's method of estimating solar temperature, the mid-summer heat of the northern hemisphere due to solar radiation, was from 40° to 50° higher than it now is. His layer of snow must therefore resist, not merely our present heats, but temperatures ranging from 100° to 150° Fahrenheit.

The remainder of the argument can be dealt with quite briefly, because it is based on the utterly fallacious results we have just described. The northern hemisphere being cooler the trade winds are thrown farther south. The Gulf Stream being caused, in part, by the trade winds, is thrown into the southern hemisphere, and thus the northern hemisphere is deprived of this latent source of heat and its temperature falls to a point far below the normal astronomical temperature. Considering separately the propositions that a cooler northern hemisphere would throw the trade winds south, and that this change in the winds would change the Gulf Stream, they both rest on too slender a basis to be worth consideration. We cannot therefore regard Mr. Croll's theory of a connection between the form and position of the earth's orbit and the Glacial epoch as having any reasonable show of foundation. The working out of such complex theories is of the less importance that there is no astronomical reason to believe that the solar radiation has been constant during a period of a million of years.

Washington, February 21, 1876.

ART. XXXIII.—*On crystals of Tourmaline with enveloped Orthoclase;* by EDWARD H. WILLIAMS, Jr.

[Read before the Chemical and Natural History Society of Lehigh University.]

WHILE at Port Henry, N. Y., last July, visiting the newly constructed furnace at Cedar Point, I noticed large sized crystals of tourmaline in some heaps of quartz and feldspar in process of shipment up the lake.

The feldspar was orthoclase, and of two varieties: one white and compact; the other reddish and much weather-stained; the cleavage planes, especially the basal, were more or less covered with a film of sesquioxide of iron. The crystals of tourmaline in the quartz were simple prisms. Those in the feldspar, and in the second variety in particular, were peculiar; when the feldspathic matrix was fractured they readily separated from it, and proved to be mere shells of tourmaline filled with feldspar.

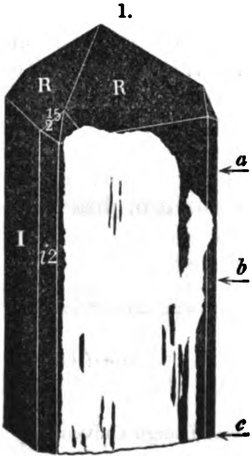
From want of time I was then unable to visit the locality from which they were taken. When again at Port Henry I

found that the minerals came from a quarry worked by Messrs. Roe and Witherbee, five miles west of the town, and about 1500 feet above the lake.

The tourmaline which presented the peculiarity was mainly in the reddish feldspar, that in the white variety being, as a rule, solid. The tourmaline occurs in long prisms with rarely more than one termination. The observed faces are: Rhombohedral, $\frac{1}{4}$, $1(R)$, $-\frac{1}{2}$; scalenohedral, $-\frac{1}{2}^{5}$; prisms, I, i-2, i-$\frac{5}{4}$. The common form is shown in Fig. 1. The crystals are commonly distorted, and are frequently terminated by but a single rhombohedral plane. Specific gravity, 3·11. Fuses before the blowpipe easily, with intumescence, to a dark bead.

In the specimens obtained, there seem to be two varieties of combination of the feldspar with the tourmaline: in the first, the tourmaline has imposed its form upon the feldspar; in the second, each has influenced the other.

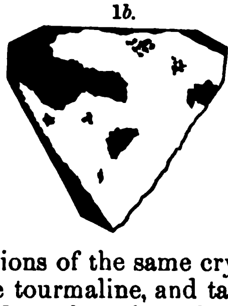
1.



There are two types of the first variety. Fig. 1 shows the tourmaline with a solid termination, and the enclosed feldspar pierced with small tourmaline prisms which descend from the solid end with their vertical axes parallel to that of the enclosing shell. These shafts, as well as the shell, decrease in thickness as they recede from the head. The tourmaline has thus a pyramidal cavity filled with feldspar; and in one instance this cavity is terminated by a face of -1. The shell is absent in places, with the feldspar apparently crystallized according to the prismatic planes of the tourmaline. In figure 1, the dark and light parts represent tourmaline and feldspar respectively;

1*a*.

1*b*.



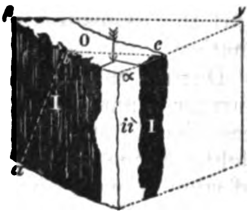
1*c*.

figs. 1*a*, 1*b*, 1*c* are sections of the same crystal (fig. 1) parallel to the basal plane of the tourmaline, and taken at the points indicated by the letters *a*, *b*, *c*; they show the gradual disappearance downward of the tourmaline.

In the second type the rhombohedral faces, as well as those of the prism, are shells, and the tourmaline does not seem to decrease in thickness with its distance from the termination. After removing the shell from these combinations the enclosed feldspar has been obtained having the form of a distorted tourmaline crystal.

Under this second variety there are cases in which the tourmaline prism encloses the feldspar and has no terminations. The feldspar often replaces the tourmaline, as is seen in Fig. 2, where the angles between the prismatic faces are distorted; one face is found parallel to a cleavage plane, usually *i-ĭ* of the orthoclase. In the figure the angles $\alpha\beta\gamma$ and $\beta\alpha\gamma$ are respectively 45° and 90°; the tourmaline prism is perpendicular to the basal plane of the feldspar; the edge toward the eye has been replaced by the orthoclase, while the tourmaline makes a re-entering angle behind it at the arrow-point; the plane *abc* is the cleavage plane parallel to *I* of the feldspar. These prisms are readily separated from their feldspathic matrix, and cleave parallel to its basal plane; each section thus given shows an uneven shell of tourmaline that in places entirely disappears. In all the cases mentioned the cleavage of the enclosed feldspar is parallel to that outside.

2.



3.

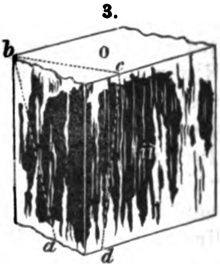


Fig. 3 shows where the tourmaline has been deposited on a cleavage face of the feldspar, and covers about one square inch; the vertical edge toward the observer is rounded, and presents no measurable angle; the plane *abcd* is a cleavage plane parallel to *i-ĭ* of the feldspar. In one instance the feldspar inside the tourmaline encloses another shell of tourmaline filled with orthoclase.

The few specimens thus far obtained seem to point to simultaneous crystallization. There is no law governing the relations in position of the two minerals; for, in the same mass of matrix, there are crystals of tourmaline whose vertical axes make with the basal plane of the orthoclase angles varying from 0° to 90°. Some of these enclose the feldspar in prisms whose angles correspond exactly with those of theory, while others are distorted and are found between the cleavage planes of the feldspar. A more extended study of these interesting forms, afforded by a greater number of specimens, may throw more light on this singular combination.

Philadelphia, Dec. 28, 1875.

ART. XXXIV.—*The Conglomerate Series of West Virginia;* by WILLIAM M. FONTAINE.

IN the May and June numbers of this Journal for 1874, I gave some account of the strata which, on New River, West Virginia, underlie the massive sandstone exposed at the Falls of the Kanawha. This account was necessarily imperfect, since at the point examined the base of the series was not exposed, and the exposures were very unfavorable for a detailed examination.

During the past summer I revisited this field, and made further examinations, at points more to the east, with such success that I am now able to present a detailed section of this field. Since the white sandstone of the Falls is the equivalent of what is everywhere called "the Conglomerate" of the Coal Measures, it might to some seem more fitting to call the rocks in question "Sub-conglomerate," or "Lower Carboniferous." In West Virginia, the strata which occupy the interval between the floor of the productive coals and the Devonian, are so greatly expanded, and so much diversified, that these terms are not definite enough to distinguish them. Besides, this New River system occupies precisely the horizon which is elsewhere commonly filled by conglomeritic sandstone alone, lying, as it does, between the red shales of the Umbral, and the lower productive coals. For these reasons I prefer to use the name "Conglomerate Series" for it. For like reasons it will be necessary to retain the names "Vespertine" and "Umbral," of the first Pennsylvania Survey, in describing rocks equivalent to those bearing these titles in the above named survey. A single instance will show this necessity. The system about to be described contains important coals. We find also far below them, in the Vespertine of Montgomery County, Virginia, near the White Sulphur, West Virginia, and elsewhere, well developed coals. To call these Sub-conglomerate or Lower Carboniferous coals would fail to distinguish them.

In my second visit to this region I made a re-examination of the strata at Sewell Station, the point at which most of the facts given in my first paper were obtained. In this last visit I found the strata quite well disclosed in the cuttings of the "Incline," made since my previous inspection. I also made a careful and detailed examination of the same strata at Quinnimont, a point on the Chesapeake and Ohio Railroad, distant by railroad twenty-one miles to the east of Sewell Station, but about ten miles by air line.

While the base of the series is not exposed at Sewell Station, yet, owing to the fact that the westerly dip is more rapid than

the fall of the river, even the underlying Umbral red shales are fully disclosed, and the entire series in question is contained in the lofty hills at Quinnimont, while in their summits they still retain a small remnant of the lower productive coals, with one and sometimes two coal beds.

While making my examination at Quinnimont I received valuable aid from Mr. S. F. Morris, C. E., and I take this opportunity to make my acknowledgments to him. Mr. Morris had, by levelling, determined the height of many points, and examined the character of the strata around Quinnimont, in behalf of the company owning the furnace and coal mine at that point. The data which he kindly put at my disposal were of great assistance in checking my own observations.

During the same summer I also made an examination of the country to the east of the Quinnimont, especially that portion in the vicinity of the White Sulphur Springs, Greenbrier County. It will perhaps be well to give here some of the facts thus obtained, bearing on the general geology of the region, in order more clearly to define the relations of the series to be described in this paper. In order to do this I will commence at the east and proceed west along the line of the Chesapeake and Ohio Railroad, whose general course is across the strike of all the strata underlying the rocks in question.

We may for a clearer exposition commence at Lewis Tunnel, a point six miles east of the White Sulphur. Here we find Vespertine strata which run in a narrow belt along the east face of the main Alleghany range, and contain the small coal beds, and plant-bearing shales, found near the Tunnel. The main range and the country westward for twelve miles is occupied by highly disturbed Devonian strata, mainly Hamilton, Portage, and Chemung, with probably the Catskill group. In the center of this belt the Springs are situated. Six miles west of the Springs, we find, on the east side of a small creek, highly contorted Devonian strata, and on the west side within 100 yards, the upper portion of the Vespertine, dipping gently eastward toward the contorted Devonian. Just above the Vespertine, in the hill across this stream, the base of the Umbral or Lewisburg limestone may be seen. The contortions and other evidences of great disturbance which follow us from the east up to this point now cease, and throughout the wide belt of country lying between this point and the Ohio River, the strata undulate more and more gently, until before Quinnimont is reached the rolls cease to reverse the dip, but serve to keep the strata longer at the surface than they would otherwise remain in that position.

This sudden change in structure is not found here alone, although it seems to be more marked here than elsewhere. It

may be traced far to the southwest, and probably to the north, and is to be explained by the existence of a fault, apparently the most westerly of the system affecting 'the Appalachian Region in this quarter. The development of this fault seems to have, in a great measure, relieved the strata lying to the west, from the disturbing force which so highly affected them on the east and it is not necessary to suppose a gradual dying away to the westward of the lateral thrust from the east. The conditions seem to imply a certain amount of unconformability between the Devonian and Vespertine, which is not incompatible with other facts observed here.

Proceeding westward along the line of the railroad from the fault, the gentle rise of the Vespertine to the west brings into view its middle or coal-bearing portion, here also containing small coal seams. This is in the vicinity of the bridge over Greenbrier River, and explains the presence near this stream, of the coal seam mentioned by Prof. Wm. B. Rogers in his reports. The Vespertine as it crosses the stream passes into a low anticlinal, which, west of the river, finally brings down the Umbral limestone to the level of the railroad. This position it maintains for a long distance, as far as Great Bend Tunnel, near the mouth of the Hungert's Creek, Summers County, where it dips under the red rocks of the Umbral series, which in this district are greatly developed. The Umbral series seems to possess a threefold character, being at bottom blood-red shales and sandstones, in the middle, grayish, bluish and brownish sandstones and shales, mainly the former; and at top brownish sandstones, blood red and varigated shales. The shales throughout the series have the texture of marlites, and the sandstones, although chiefly argillaceous are sometimes highly siliceous, forming huge cliffs along the railroad, as seen near Richmond Falls. These three series, the Vespertine, the Umbral limestone, and Umbral shales and sandstone, thicken rapidly in proceeding from northeast to southwest. Prof. Rogers measured them in Greenbrier Mountain, Pocahontas County, a point about sixty miles northeast of Richmond Falls on New River, where the Umbral shales and sandstones are extensively exposed. With respect to the limestone I have no data for comparison but the indications are that on the railroad it is thicker than the measurement given by Prof. Rogers, viz: 822 feet. For the Umbral shales and sandstones in Pocahontas he gives a thickness of 1,310 feet. My estimates along the line of the railroad, which, however, have not the accuracy of measurements, give for this series a probable thickness of 1,450 feet in the vicinity of Richmond Falls, distributed as follows: 1. Lower red shales and sandstones, 320 feet; 2. Middle gray and greenish sandstones, 820 feet; 3. Upper red and variegated shales, 310 feet. If we com-

pare this series with the character of the Umbral in the vicinity of Blossburg, as given by H. D. Rogers, we find an almost identical distribution of similar strata. The upper portion of the Umbral continues to be shown up to a short distance west of Quinnimont, where the prevailing westerly dip takes it out of sight. These upper strata form the base of the hills around Quinnimont, contrasting strongly in all their physical features with the overlying conglomerate series. This latter, whose entire thickness lies above the level of the river at this point, gradually sinks as we pass west, down stream, being kept above water level for a long distance by several broad rolls. It finally passes out of sight two or three miles below Kanawha Falls, and is succeeded by the series of the Lower Productive coals in the Kanawha Region. In this latter series there is a four-feet bed of coal, about forty feet above the massive sandstone which closes the conglomerate series. This is the equivalent of coal B of Lesley. This bed still remains uneroded in the tops of some of the high hills around Quinnimont.

About two miles down the river, on the Raleigh County side, Piney river empties into New River. A well graded road from the mouth of this stream, passes over the outcropping edges of the entire conglomerate series, and the numerous cuttings made in grading afford excellent exposures of almost every member of the series throughout its entire thickness. My section was made along this road. It was verified by a second section taken at Quinnimont by another road, which also passed over the entire series. These two sections were compared with observations made at Sewell Station, and with measurements made by Mr. Morris. The data in the cases in the section, marked as not seen, are given on the authority of this gentleman. The dip is northwest about fifty feet to the mile.

Section from the mouth of Piney River, Raleigh County.

21. Upper conglomerate, 150–200 feet.
20. Black slate, with thin coal partings, coal not seen, 10 feet.
19. Olive gray sandstones and shales, 100 feet.
18. Dark blue slates and sandstones, 80 feet.
17. Quinnimont coal seam, or coal No. 9, consisting of semi-bituminous coal, 4 feet; fire clay, $2\frac{1}{2}$ feet; and at bottom, splint coal, 14 inches, $=8$ feet.
16. A thick mass of rocks not fully exposed, which may be divided as follows: 16 *e*, olive gray shaly sandstones, 40 feet; 16 *d*, coal 8, not seen, given as 20 inches thick; 16 *c*, bluish sandy shales, 60 feet; 16 *b*, coal 7, not seen, given as 2 feet thick; 16 *a*, gray sandstone, 50 feet. Total, 154 feet.
15. Fire clay and a 12-inch outcrop of coal, seen imperfectly exposed, given as 2-$4\frac{1}{2}$ feet of imperfect splint coal, coal No. 6, $=2$–$4\frac{1}{2}$ feet.

14. Coal system; at bottom interstratifications of coal and slate, with one seam one foot thick; (coal No. 5), and on top, flags passing into firm sandstones. Good plant impressions occur here. Thickness, 80 feet.
13. Olive marlites, 40 feet.
12. Massive firm gray sandstones, 50 feet.
11. Coal No. 4, not fully exposed, given as 2½ feet thick.
10. Firm gray flags and sandstones, 90 feet.
9. Coal system, coal No. 3; at bottom interstratifications of thin coals and strata; on top, shales, flags and sandstones, 80 feet.
8. Gray sandstones, 75 feet.
7. Ferruginous limestone, 2 feet.
6. Variegated marlites, 40 feet.
5. Bright red shales and marlites, 30 feet.
4. Coal system, coal No. 2, consisting of coal 8 inches, slate 2½ feet, coal 8 inches, sandstone 8 feet, and at bottom coal and slate 1 foot; total =13 feet.
3. Olive and reddish sandstones, passing below into olive marlites, 100 feet.
2. Black slate, not seen, said to contain 18 inches of coal, (coal No. 1), given as 11 feet thick.
1. Lower conglomerate, 80 feet. Total =1,197 feet.

Under the lower conglomerate is found a transition series, of which the following is a section determined mainly at Quinnimont, where the strata are more fully exposed.

Transition Series at Quinnimont.

2. Black fissile slates and shales, 20 feet.
1. Thinly laminated gray flags and calcareous shales, with drifted leaves of Lepidodendra near the base; and near the top having numerous impressions of marine shells, while at the top it passes into carbonaceous shales with strings of coal, leaves of Lepidodendra and other impressions too much obscured for determination, 50 feet. Total =70.

To complete the section of the strata exposed in the vicinity of Quinnimont, I give below a section of so much of the Umbral series as is to be seen there.

Section of the Umbral Series at Quinnimont.

3. Variegated marlites with some nodular limestone, 70 feet.
2. Gray calcareous sandstone, 20 feet.
1. Bright red shales, seen 50 feet. Total =140 feet.

Some of the above mentioned strata merit a more particular description, which I will now give.

I make in this place no further mention of the remnant of the Lower Productive coals found in this vicinity, but refer to my former paper, where some account was given of their

character as found in the Kanawha Valley. It is not known how much farther east they extend, but it cannot be to any considerable distance. No. 21 of the conglomerate series is the only persistent member. As it is found everywhere throughout the Appalachian Coal Field, being in many places the sole representative of the series, and as it is always at a uniform distance below the lowest workable coal-seam of the Lower Productive coal it would seem to been titled to be called, as it has been, "The Conglomerate of the Coal Measures." In Raleigh County, and along New River, it is usually a coarse white sandstone, with some conglomeritic portions in its middle and upper parts. In its lower portions it is more flaggy and argillaceous. It varies in thickness from 150 to 200 feet. In the section I have in my summation taken it at the lower figure.

No. 20, near Piney River, shows at its outcrop only black slate. It has been opened near Quinnimont, and is said there to contain thin strings of coal. Nos. 20, 19, and 18, have no features of special interest.

No. 17. This is the coal-seam which is worked extensively at Quinnimont, where it is coked and used in the furnace at that place. It is the most persistent and best developed seam of the series, being easily recognized everywhere in this region by its peculiar structure. From the flaggy sandstones over this bed at Sewell Station were obtained the plants of Devonian type mentioned in my former paper. At Quinnimont I could find none of these, and it is there remarkably free from plant-impressions of all kinds. In Raleigh also it showed no plants. At Sewell Station, this seam was at first opened for the purpose of working it, but was soon abandoned, owing to an apparent thinning out which was in fact caused by a slide.

No. 16, on the Raleigh road, was not fully exposed owing to slides, which also obscure its outcrop at Quinnimont. It presents the subdivisions founded on the character of the sandstones given in the section, but the coal beds are given on the authority of Mr. Morris, and others, who claim to have opened them. I have no doubt of their existence, for at Quinnimont the black slate accompanying 16 *d*, or Coal No. 8, was seen.

No. 15 was only partially exposed at its outcrop on the Raleigh road. Next to the Quinnimont seam, it appears to me to be the most promising seam of the field. The fire-clay is of fine texture, and sharply distinct from the coal, features not usually seen in the coals of this series.

No. 14, (Coal 5.) This presents in a marked manner a feature very common in this field. The coal at its base exists in the form of numerous interstratifications of coal in thin partings, and black carbonaceous shales; the whole being topped by strata which become more and more siliceous, and firmer as they ascend. There is enough carbon diffused through the

base of this mass to make an important bed of coal, were it collected in one mass. The condition of things here shown indicates that there was no deficiency of vegetable matter, but that the alterations of level were too rapid to permit a great accumulation of coal in one mass. The same features to a greater or less extent are shown in every coal bed of the series, and it is safe to say that the instability alone of the surface, prevented the accumulation, in this series, of coal beds as thick as those found in the more productive series which lies above it. Many good plant impressions occur here.

No. 11, from its outcrop, seems to be a promising bed of coal. Its thickness was not fully disclosed. Mr. Morris gives it as two and one-half feet thick. It shows at its base Stigmaria rootlets.

No. 10, stands out in high cliffs. Some of the other sandstones of the series also present firm perpendicular outcrops.

No. 9, is well exposed on the road in a high cliff. It presents the same features as number fourteen, even more strikingly. Numerous thin seams of coal, intermixed with carbonaceous shale, some of them three or four inches thick, form the lower portion for a space of seven feet. Vegetable matter in the form of films of coal, and impregnations of the sandstones and shales, occur to the height of thirty feet. Only a few Lepidodendron leaves were found here.

No. 8, is a massive and siliceous sandstone, forming high cliffs, and resembling to some extent No. 21.

Nos. 6 and 5, are interesting for the recurrence here, in the middle of this coal-bearing series, of the same conditions which prevailed in the formation of the upper part of the Umbral series. These two strata are most strikingly like the red and variegated marlites and shales, found in that portion of the Umbral, and might easily be mistaken for them.

No. 4, is well exposed on the Raleigh road. No plants were found in it.

No. 2, is not exposed anywhere so far as I have seen. The interval occupied by it, lies between the massive rock, No. 1, and the crumbling strata of No. 3, which are especially prone to slide down over the precipitous cliffs formed by No. 1. Hence at all the places examined by me, this portion was buried under a mass which had come down from above. Its character is given on the authority of Mr. Morris.

No. 1. This member of the series I consider to be the base of the conglomerate series. It is one of the most prominent features in the hills, standing out as it does, not far above their bases, in immense precipitous ledges. It forms the first stratum, which indicates a decided change from marine to terrestrial conditions. It is much nearer a true conglomerate than No. 21, for many of the layers contain pebbles, a half inch in diameter.

It is usually a coarse, open-grained, purely siliceous sandstone, lying in very thick beds. Near the bottom it is brownish in color, but above it is white, having many ferruginous stains. In many parts of this sandstone, particles of carbonaceous matter, in the condition of charcoal, are seen, produced from drifted fragments of trunks and limbs of trees. This condition of the vegetable matter is no doubt due to the ready escape of the bituminous matter from the porous sandstone. Sometimes pretty large angular fragments of the brown sandstones of the Umbral are found associated with these fragments of trees, and in some cases the pebbles of the conglomerate portions are of limestone. This rock is no doubt the heavy sandstone mentioned by Professor Rogers as found some distance to the east of this point, forming the summit of Little Sewell Mountain.

Underlying this rock is found a series of beds which are evidently the products of a period of transition. They are well exposed near Quinnimont, and exhibit some interesting features. No. 1 of this series is a thinly-laminated, argillaceous, gray sandstone in its lower part, but becomes more and more calcareous toward its upper portion, where numerous impressions of shells are found, a list of which will be given farther on. At its summit, which is not seen at Quinnimont, but is well exposed on the Raleigh road, there is a good deal of vegetable matter mixed with the shale, and which is the product of plants which have grown on the spot. This is the lowest indication of an attempt at coal formation, seen in this region. From the indications, there is little doubt that in some places this horizon may show a little coal. Professor Rogers mentions that near the top of Little Sewell, and immediately over the red shales of the Umbral, he saw a small coal-bed. It is no doubt the stratum now described. The other strata given in the sections above present no points of interest.

From this account of the coal-bearing series in question it will be seen that it occupies the horizon of the so-called "Coal-measures Conglomerate," and it would seem to be simply a greatly expanded portion of this widely extended formation. Lying between two huge plates of massive sandstone, either of which has equal claims to the title of conglomerate, the name which I have given it seems justified.

Almost no exploration has been made in the country to the east of Quinnimont, and hence the limits in that direction of this series cannot be given. That it does extend farther east is known. Since my inspection last summer, I have been informed that a five-foot bed of coal is found near Hinton, 800 feet above the level of the river. Hinton is near the mouth of Greenbrier river, about fifteen miles farther east than Quinnimont, measured in an air-line across the strike of the strata.

To the southeast and south, it is found in the counties of

Wise, Russell, and Tazewell, as may be seen from the account of these counties given by Professor Lesley, in his paper read before the Am. Phil. Soc., April 21, 1871. Professor Lesley shows that under the so-called "Sheep Rock" in Wise county, about 700 feet of coal-bearing rocks are disclosed, with the base not shown. The "Sheep Rock" is No. 21 of the Piney River section. In this space two coal beds are to be seen; one, a six-foot bed, lies at the very base of the hills, and the other, a two-foot bed, is a short distance above it. A similar formation exists in Russell and Tazewell counties. These coals are not to be confounded with the beds seen in Montgomery county, for the latter are found in the Vespertine strata, and are of the same age with those near the White Sulphur in Greenbrier county. The basin, in which these conglomerate coals were formed, evidently extended still farther east than the counties described in Professor Lesley's paper, as the considerable development of this series in them shows. But in the more easterly extension of the field, the number of seams have diminished, especially in the upper part. On New River in Raleigh county the most important coals are found within 700 feet below the upper ledge.

As we proceed northward, along the eastern outcrop of the series, it has been more extensively affected by erosion, and has been swept off from the greater part of Monroe and Greenbrier counties, these being occupied mainly by the Umbral shales and limestone. Professor Rogers mentions finding at the top of Greenbrier Mountain, in the northeast part of the county of that name, a massive sandstone resembling the conglomerate. This is no doubt a remnant of the series. North of this point, in Rich Mountain, in Randolph county, the entire series is presented, capping the mountain, according to Dr. Stevenson. But here it has undergone an important modification, from the loss of the shaly central portion, and the almost entire disappearance of the coals.

[To be continued.]

ART. XXXV.—*Results of Experiments on the Set of bars of Wood, Iron, and Steel, after a Transverse Stress;* by WM. A. NORTON, Professor of Civil Engineering in Yale College.

AT intervals, during the last two years, I have carried on a systematic series of experiments, with the view of determining the laws of the set of materials resulting from a transverse stress under varied circumstances. The experiments were made with the testing machine which I devised several years since, for the purpose of experimenting on the deflection of bars under a transverse stress. A detailed description of this

machine is given in the Proceedings of the American Association for the Advancement of Science, Eighteenth Meeting, Aug., 1869, (p. 48). The depressions of the middle of the bar experimented on,—while under a transverse stress, or remaining after the stress has been withdrawn—are measured by it to within $\frac{1}{10000}$ of an inch. The experiments on set have been fully discussed in two papers read before the National Academy of Sciences, Washington, (April, 1874 and April, 1875). The first paper set forth the results of the experiments on bars of wood, and contained a detailed account of the course of experiments instituted for the purpose of detecting instrumental errors, and of the precautions taken to reduce the incidental errors, from variations of temperature and other causes, to a minimum. The second paper discussed the experiments on the set of bars of wrought iron and steel; which gave results generally similar, under corresponding circumstances, to those obtained with wood. I propose, in the present communication, to give a succinct statement of the general conclusions that follow from the whole discussion.

The experimental investigation was prosecuted under three general heads:

I. Sets from momentary strains.

II. Sets from prolonged strains.

III. Duration of set; and variation of set with interval of time elapsed after the withdrawal of the stress.

Each of these embraced several special topics of inquiry. The bars used in most of the experiments consisted of one of white pine, 3 in. by 3 in and 4 ft. long; another of wrought iron, ½ in. wide, 1 in. deep, and 4 ft. long; and a third of steel of the same dimensions. The discussion of the entire series of experiments has brought out the following results, as alike applicable to bars of wrought iron, steel, and white pine.

1. The immediate set,—that is, the residual deflection which obtains immediately after the transverse stress is withdrawn,—increases in nearly the same proportion as the stress applied; until this exceeds a certain amount, beyond which the set increases according to a more rapid law than that of proportionality to the strains. It is to be understood here that the varying strains are applied at considerable intervals of time.

2. The immediate set augments with the duration of the stress, up to a certain interval of time. In the experiments with white pine, the duration of strain which gave the maximum immediate set, varied, with the strain, from ten minutes to one hour. The immediate set resulting from a prolonged strain, was found to be from five to nine times as great as that which succeeded a momentary strain.

3. The residual depression below the original line of the bar,

is greater if the stress is reached by a series of increasing weights than if the full stress is directly applied.

4. When the same strain is repeated on the same bar, after a short interval of time, the set first obtained is not augmented, unless the load applied exceeds a certain amount, varying with the material and dimensions of the bar. With loads greater than this limit each repetition of the load augments the total set. The amount of the increase varies with the interval of time since the previous application of the load and the number of previous applications.

5. The set, or residual depression of the middle of the bar, experiences marked variations as the interval of time subsequent to the removal of the stress increases. When the immediate set is less than about 0·0005 in. it passes off in a few minutes (10 m. or less). When it is greater than this it habitually varies as follows: it invariably decreases for a short interval of time, and then ordinarily increases for a longer interval, with moderate fluctuations. The period of decrease varies from about 5 m. to 20 m.; and is the longer in those instances in which the stress is prolonged. The subsequent increased set, or augmented depression of the line of the bar, may attain in less than an hour to an amount even greater than the set observed immediately after the stress is withdrawn. In some of the experiments the depression increased until it came to be about double that first observed. The proportionate increase of set is usually, however, much less than this. This increase of set is eventually succeeded by another decrease. These remarkable fluctuations observed in the line of the bar were more conspicuous in the experiments with white pine, than in those with iron and steel. The difference was, however, only in degree. Under similar conditions the general character of the fluctuations was the same whichever material was used. The fluctuations observed with the bars of iron and steel, as well as with the wooden bar, far exceeded any errors to which the observations were liable. They were also much too slow, and too prolonged, to be regarded as simple vibrations of the bar, consequent on the removal of the downward pressure.

6. Abnormal variations from the general law of variation of the set just noticed, may occur under especial circumstances. Such deviations were observed after the bar had been subjected to repeated strains from day to day. Under these circumstances the bar may be in such an abnormal condition that the set observed immediately after the stress is withdrawn may pass off rapidly, and the line of the bar may even rise considerably above the position held when the stress was applied—though not above its original line some days previously, before any strain was applied.

7. When the load, or stress at the middle of the bar, exceeds a certain amount, the set resulting from one or more applications of the load on any one day is not only still discernible on the following day, but the actual result may be that the middle of the bar may be lower than at the close of the observations on the previous day. Such effects were observed, in the experiments with white pine, when the load was sufficient to produce a longitudinal strain on the upper or lower fibers of 500 lbs. per square inch; and in the experiments with the steel bar, resting edgewise on its supports, when the strain on the outer fibers amounted to 1500 lbs. per square inch.

8. Repeated applications of the same load, from day to day, are attended with an indefinite augmentation of the residual depression of the middle of the bar, if the load exceeds a certain amount. When a smaller load is similarly applied, the set attains after a few days to a maximum, and subsequently subsides more or less. The load answering to the critical point here referred to, is obviously the maximum safe value for a variable load that can be applied, with an indefinite number of repetitions, to the bar. In the case of a white pine stick (3 in. by 3 in., and 4 ft. long) the experiments show it to be less than $\frac{1}{4}$ the theoretical breaking load. Under repeated applications of 500 lbs. (or about $\frac{1}{4}$ the theoretical breaking weight) the set steadily increased from day to day—that is, the middle of the stick became more and more depressed—during the entire period (seven days) that the prolonged effects were noted. Under daily repetitions of a load equivalent to $\frac{1}{16}$ the breaking weight, the depression increased for three days, and after another interval of three days the stick had recovered its original line. The depressions here referred to are those which obtained on the morning of each day just before the first application of the stress on that day.

9. In connection with the phenomena of set which have been signalized, it is important to note that during any interval in which a bar was kept under a transverse stress, the resulting deflection commonly experienced a continual variation. In general the deflection increased as the strain was prolonged. But the deflection of the steel bar in some instances diminished, under the prolonged strain. This unusual result was apparently dependent on some molecular condition of the bar, induced by previous strains. The comportment of the wrought iron bar, as regards varying deflection under a continual strain, was not particularly examined.

It is also noteworthy, in this connection, that the deflection resulting from any single stress was found to be more or less dependent on the previous strains to which the bar had been subjected. The wooden bar, when it had been exposed to a

cross strain not long before, was generally in a condition to suffer a greater deflection than it had before experienced under the same load. The same was true of the steel bar during several successive days of experiments with loads of 4 lbs. and 6 lbs.; but as the result of these repeated strains the bar came eventually to be in a condition in which each renewal of the stress gave, for the most part, a less and less deflection.

10. It is apparent from the foregoing experimental results, that every application of a transverse stress to a bar must induce some change in its molecular condition, which continues, with variations that may be either progressive or fluctuating, for a greater or less interval of time. The duration of sensible influence varies with the amount and duration of the stress. For the smaller strains it is but a few minutes; for the larger several days. The prolonged influence of strains applied from day to day to a bar, was apparent from the fact that the same stress did not on different days produce either the same deflection or the same set. It was strikingly shown in the experiments with the steel bar by causing the bar, to which loads had been repeatedly applied for several previous days, to rest on its opposite side, and comparing the deflection and set with those obtained immediately before the reversal. It was found that the deflection produced by $18\frac{1}{8}$ pounds was $\frac{1}{16}$ greater than the deflection produced by the same weight just before the reversal; and the set obtained was now many times greater than before. The deflection also now increased with a prolongation of the strain, whereas it before decreased. Also the set now increased for a considerable interval of time after the withdrawal of the strain, whereas it before decreased.

11. There was no discernible limit of elasticity, revealed by the experiments, with either wood, iron, or steel. A perceptible set obtained, with each material, immediately after the stress was removed, however small its amount, until the set fell below the lowest possible determination of which the apparatus was capable (viz: $\frac{1}{10000}$ of an inch, as the experiments were ordinarily conducted.) To test the question still farther, the delicacy of the measuring apparatus was largely increased, by the adaptation of a device for magnifying the movements to be observed; and it was found that the least perceptible immediate set was still limited only by the capability of detecting, with the apparatus, minute displacements.

If we take for the limit of elasticity the condition of things at which a *permanent* set is obtained, the case is different. Thus it was found that the set which subsisted after the pine stick (3 in. by 3 in. and 4 ft. long), had been loaded at its middle with 200 pounds ($\frac{1}{16}$ the theoretical breaking weight), eventually passed off entirely. This was the case whether the stress was momentary or prolonged, and whether it was applied but once

or repeatedly. But with a load of 500 lbs. a permanent set was obtained, as the result of a single application of the stress; and repetitions of the stress were attended with a continual increase in the depression of the middle of the bar. It may accordingly be affirmed that a practical limit of elasticity exists, but not a theoretical one.

12. If a bar, on the withdrawal of a transverse stress, fails to recover its original line of position, or, technically speaking, has a set, it is plain that its integrant molecules have not returned precisely to their original positions, and that the distances between contiguous molecules have either increased or diminished—increased in the line of the longitudinal fibers that have experienced a tensile strain, and decreased in the line of those which have experienced a compressive strain. Now we have seen that, as the result of a series of increasing transverse stresses, the set increases continuously with the stress, from the lowest amount capable of detection with the measuring apparatus employed. We must therefore conclude that, after the application of a series of increasing strains, in which the molecules are relatively displaced by minute fractions of their intervening distances, they take up, when the strain is removed, a series of new positions of equilibrium, differing by excessively minute degrees from those previously occupied. We may draw the same conclusion from the experiments on the set produced by a series of direct tensile and compressive stresses, made by Hodgkinson, Chevandier and Wertheim, and other experimenters. This general conclusion, to which experiments on set, under every variety of strain, conduct, leads to the inevitable inference that *the effective forces exerted by the molecules on one another have suffered some change of intensity, in consequence of the stress applied to the bar under experiment.* Viewing the residual displacement of the molecules, in their relative positions, as a mechanical problem, we are constrained to regard the effective molecular forces, that take effect at a given distance, as having acquired a different intensity. We have confirmatory evidence of this induced molecular condition of the bar in the fact that all the diverse effects, which may ensue on subsequent applications of a transverse stress, are found to be either less or greater than those previously observed under similar conditions.

13. The fluctuations that have been noticed as occurring in the set with the lapse of time, reveal the fact that the change in the intensities of the effective molecular forces, which results from the temporary application of the stress, is not permanent but fluctuating; and may, according to the amount of the stress applied, rapidly pass off, or, after a partial collapse, be slowly recovered again. It should be observed, however, that the curious fact of the increase of set which ordinarily succeeds the first sudden fall, may be in part attributable to the gradual

propagation inward of the greater disturbed condition of the molecules of the upper and lower fibers.

14. The general correspondence in the phenomena of set and altered deflection, that obtain with different materials altogether precludes the idea that they may result, either wholly or in a considerable degree, from irregular strains subsisting in certain parts of the bar before the stress is applied, and which are more or less modified by the stress; as some persons have conjectured. The change that supervenes must be a general one, or one in which all the molecules participate, though in diverse degrees according to the amount of molecular displacement. The especial character of the change, for each individual molecule, must depend upon the kind of strain to which the molecule is exposed, whether tensile, compressive, or shearing; and not on the nature of the material subjected to strain.

15. If, as experiment has established, when the distance between two contiguous molecules has been forcibly altered, the molecules, when again left to their mutual actions, no longer exert, at the same distance, effective actions of the same intensity as before, it is apparent that *the molecules in the act of displacement have experienced some change, either in their dimensions, or in their internal mechanical condition.* This change must result from the change that took place in the mutual action of the molecules when they were urged nearer to each other, or separated to greater distances. It must be experienced by the ultimate molecule, whether this be indentical with the integrant molecule or not—that is whether we regard the integrant molecule as a single ultimate molecule, or as a group of ultimate molecules. For it is plain that a group of ultimate molecules could not undergo an internal change, that abides after all external actions have ceased, unless its constituent molecules have suffered a change, by reason of which they no longer act upon one another with the same intensities of force as before.

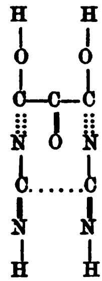
It is well known that with Physicists the "chemical atom" has come to be replaced by the "ultimate molecule." Of the probable physical constitution of the ultimate molecule different conceptions have been formed. To those Physicists who regard it as made up of a limited number of precisely similar atoms, endued with unvarying forces—of attraction at certain distances, and repulsion at other distances—I leave it to reconcile this conception with the legitimate inference to be drawn from experimental results, that the ultimate molecule is liable to a change of mechanical or physical condition, with every slight displacement it may experience—a change which subsists after the constraining cause of the displacement has ceased to act; and may, under different conditions, either be permanent, or gradually subside with fluctuations.

ART. XXXVI.—*On the constitutional formulæ of Urea, Uric Acid, and their derivatives;* by Professor J. W. MALLET, University of Virginia.

[Continued from page 194.]

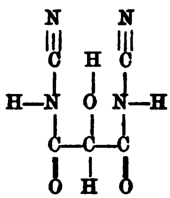
FOR uric acid itself, $C_5H_4N_4O_3$, the di-ureide of mesoxalic acid, I would propose the formula (No. 1).

1. Uric acid (di-basic).

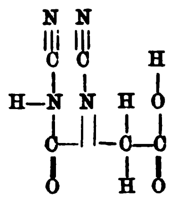


Nos. 2 to 9 show, for the sake of comparison, some of the numerous formulæ which have of late years been given for this important substance.

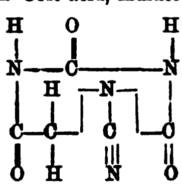
2. Uric acid, Baeyer* and Kolbe.†



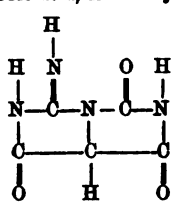
3. Uric acid, Hüfner.‡



4. Uric acid, Mulder.§

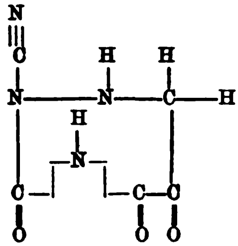


5. Uric acid, Erlenmeyer.‖

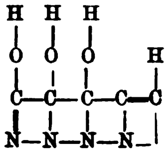


* Ann. der Chem., cxxvii, 235.
† Journ. für prakt. Chem., II, i, 134.
‡ Journ. für prakt. Chem., II, iii, 23.
§ Bericht. d. deutsch. chem. Gesellsch., vi, 1237.
‖ Münch. Akad. Ber., ii, 276.

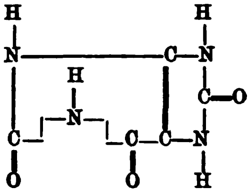
6. Uric acid, Strecker.*



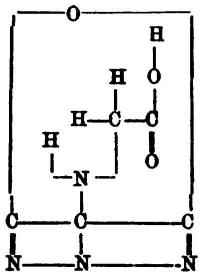
7. Uric acid, Gibbs.†



8. Uric acid, Medicus.‡



9. Uric acid, Drechsel.§



While each of these formulæ possesses advantages for the explanation of certain cases of decomposition and certain derived products, an attentive study will show, I think, that all are more or less defective as to accounting in the simplest way for the well known basicity of uric acid itself, bringing it into harmony with the general structure of non-nitrogenous organic acids, recognizing a close relationship to the 3-carbon series, and preserving as far as possible simplicity and symmetry in the supposed arrangement of the atoms.

In connection with the formula I propose it may be noticed: that it does account for uric acid being dibasic; that it derives it as directly as possible from a residue of the 3-carbon mesoxalic acid; that it explains simply most of the observed decompositions of the acid; that it perhaps affords a reason, in the direct linking together of the two urea residues as well as their attachment to the acid nucleus, for the comparative stability of uric acid; and that it also suggests a cause of the difficulty of reproducing this substance artificially, since in the attempt to form a salt of urea with a non-nitrogenous acid and then remove water the basic hydroxyl might be eliminated and the normal acid type destroyed, whereas this type is pre-

* Lehrb. d. org. Chem., 1868, 800. † This Journal, Nov., 1868, xlvi, 293.

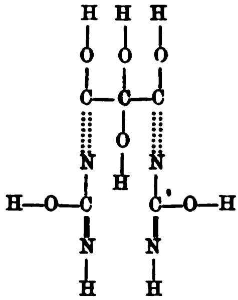
‡ Ann. der Chem., clxxv, 243; where most of the formulæ above quoted are reviewed.

§ Chem. Centralbl., 4 Aug., 1875, 493.

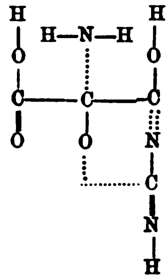
served by the different mode of attachment of the urea residues exhibited in the formula now put forward. The mode of production from uric acid of allantoine, alloxan, paraban, etc., will be seen by comparison of the preceding formulæ.

Probably uroxanic acid, $C_5H_8N_4O_6$, is represented by No. 1

1. Uroxanic acid (dibasic).



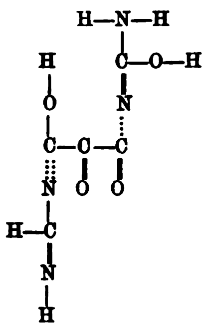
2. Oxonic acid (dibasic).



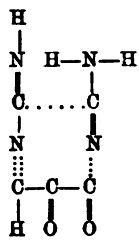
while the oxonic acid of Strecker and Medicus,* $C_4H_5N_3O_4$, produced under similar conditions, but showing by its containing only three atoms of nitrogen that it cannot include two complete urea residues like those of uric acid, may perhaps have the structure of No. 2.

The basicity of pseudo-uric acid, $C_5H_6N_4O_4$, may be explained by assuming its two urea residues differently attached, and in one of them an atom of hydrogen taking the place of hydroxyl—thus:

1. Pseudo-uric acid (monobasic).



2. Xanthine (weak base).

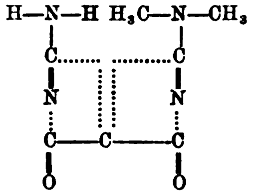


In xanthine, $C_5H_4N_4O_2$, whose empirical formula differs from that of uric acid only by an atom of oxygen, we have also two dissimilarly attached residues of urea, but the basic hydroxyl disappears altogether and with it the true acid character, while like urea itself xanthine is capable of uniting with metallic oxides as well as with acids.

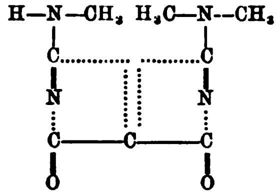
* Ann. der Chem., clxxv, 230.

This formula (No. 2) may serve to explain the fact that Strecker's di-methyl-xanthine is isomeric, not identical, with theobromine, $C_7H_8N_4O_2$, if we assume the latter to be as in No. 1, and caffeine, $C_8H_{10}N_4O_2$, as in No. 2,

1. Theobromine (weak base).



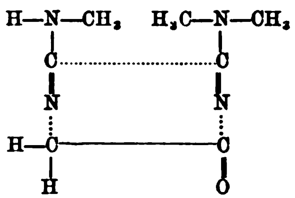
2. Caffeine (weak base).



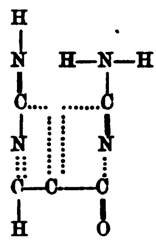
both urea residues in each of these formulæ being similarly connected with the acid nucleus. The relation to di-methyl-paraban (cholestrophan) is obvious.

We may probably assume No. 1 as the formula of caffeidine, $C_7H_{12}N_4O$ (a stronger base than caffeine).

1. Caffeidine.



2. Hypoxanthine (sarcine)—(weak base).

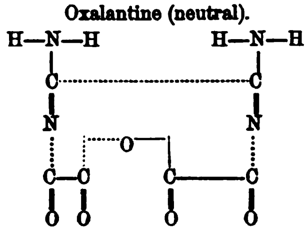


Hypoxanthine, $C_5H_4N_4O$, exhibits the same general character with xanthine, and containing one atom less oxygen may be represented as in No. 2, above.

The above formulæ for hypoxanthine and xanthine accord well with the reported production by Strecker of the latter from the former by oxidation, and of a mixture of both bases from uric acid by reduction with sodium amalgam.

Passing to the compounds in which two acid residues are united with each other and at the same time with residues of urea, we may formulate oxalantine, $C_6H_4N_4O_5$, as follows:

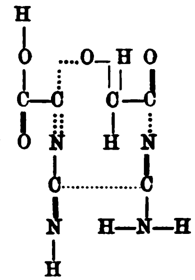
Oxalantine (neutral).



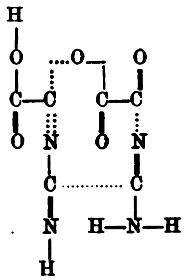
thus directly explaining the relation to paraban, and production therefrom by coalescence of two molecules with elimination of an atom of oxygen (or from a molecule each of oxaluric acid and paraban, with removal of an atom of oxygen and a molecule of water).

The union of hydantoine with allanturic acid, with separation of water, gives for alliturie acid, $C_6H_6N_4O_4$, the formula No. 1.

1. Alliturie acid (monobasic).



2. Leucoturic acid (monobasic).

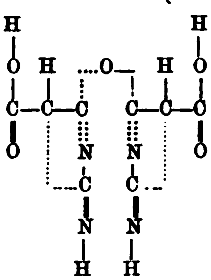


and the like union of paraban and allanturic acid leads to No. 2 for leucoturic acid of Schlieper, $C_6H_4N_4O_5$. This last formula explains the possibility at least of a difference between leucoturic acid and oxalantine, the identity of which does not seem clearly established.

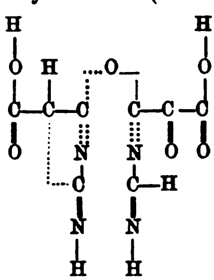
In each of the last two cases we have one ureic residue *inverted* as regards its mode of attachment to the acid nucleus when the coalescence takes place.

Two molecules of (dibasic) barbituric acid unite with separation of a molecule of water, giving rise to di-barbituric acid, $C_8H_6N_4O_5$, with unchanged basicity,

1. Di-barbituric acid (dibasic).



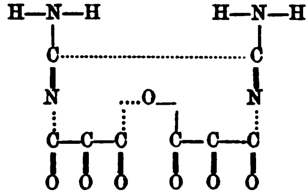
2. Hydurilic acid (dibasic).



while the union of a molecule of barbituric acid and one of dialuric acid, with *inversion* of the ureic residue of the latter and elimination of a molecule of water, gives us hydurilic acid, $C_8H_6N_4O_6$, (No. 2).

Alloxantine, $C_8H_4N_4O_7$, may be represented as

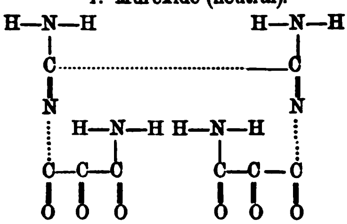
Alloxantine (neutral).



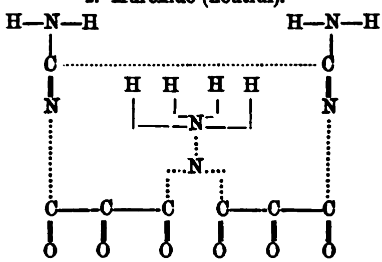
clearly exhibiting the analogy of this body to oxalantine, and its production in a similar way by the coalescence of two molecules of alloxan with separation of oxygen (or a molecule of alloxan and one of dialuric acid with the additional separation of water). The formula of Gibbs for alloxantine would seem to imply that it is a monobasic acid (or, according to the exact terms of his own definition,* tribasic).

Finally, it is difficult to suggest with confidence a formula for the problematical substance murexide, $C_8H_8N_6O_6$. If an amide character be admitted for it; and it does seem that evidence is still wanting to conclusively prove that it is an ammonium salt, especially in view of non-production of purpuric acid and the undoubted existence of isomeric iso-purpurates (and possibly other salts) which may have led to an undue assumption of identity of type between murexide and its metallic derivatives; we may perhaps assume this substance to have the formula No. 1,

1. Murexide (neutral).



2. Murexide (neutral).



in which the union of two molecules of dialuramide is effected, with elimination of hydrogen, by the linking together of the ureic carbon atoms. This view of the constitution of murexide (making it alloxantine-amide) obviously affords a simple explanation of its production from dialuramide by oxidation, from ammonium dialurate by heating, from alloxantine and alloxan by the action of ammonia, &c., and also suggests the probable

* Loc. cit.,—"cyanyl may be regarded as the acidifying term. Its quantity, therefore, determines the basicity of the acid."

ease with which isomeric changes may be brought about. If murexide be ammonium purpurate, the formula might perhaps be changed to the form in No. 2.

While the views above stated as to the structure of the numerous and interesting compounds derivable from urea and uric acid are liable to objection at sundry minor points, and in several instances other arrangements of the elements might be adopted without interference with the main idea, I believe that on the whole the constitutional formulæ set forth in this paper more nearly represent the present state of our knowledge of this group than any others which have been proposed, and especially possess the advantage of better explaining the chemical character or function of the substances referred to,* while at least equally well exhibiting the nature of the changes by which they are produced from each other.

University of Virginia, Nov. 4, 1875.

ART. XXXVII.—*On the Evidences of horizontal crushing in the formation of the Coast Range of California;* by JOSEPH LECONTE.

[Read before the National Academy of Sciences, November, 1875.]

IT will be remembered that in a former paper "On the formation of the greater inequalities of the earth's surface,"† I sustained the view that mountain ranges are formed wholly by a yielding of the crust of the earth along certain lines to horizontal pressure; not, however, a yielding by bending of the crust into a convex arch, filled and sustained by a liquid beneath, as has been supposed by some; but by a crushing or mashing together horizontally of the whole crust, with the formation of *close folds* and a thickening or swelling upward of the squeezed mass. I believe the structure of all mountain ranges, in which the stratification has not been obscured by metamorphism, would demonstrate this mode of formation.

I have long thought that the Coast Range in this vicinity is peculiarly adapted to exhibit in its structure the mode of its formation. It is destitute of granite axes, and it has been but little, in many places not at all, changed by metamorphism or overlaid by igneous ejections. A good section ought to clearly reveal its structure and its structure ought no less clearly to reveal the mode of its formation.

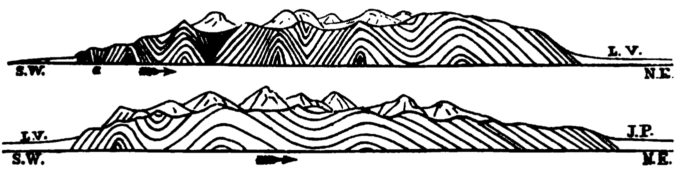
With this conviction, on the 5th of January last, in company

* The formulæ of Baeyer (in common with all those representing urea as carbamide) seem to fail in securing this advantage, although involving in part the same sort of view of the ureides as that above stated.

† This Journal, III, vol. iv, pp. 345 and 460.

with Mr. W. Jackson, a recent graduate of the university, and now a special student of mineralogy, I set off afoot, and walked very leisurely through the cut made by the Central Pacific Railroad from the plains adjoining the Bay of San Francisco through the mountains to the San Joaquin plains, a distance of about thirty miles, taking the angle and direction of the dip at every available point. The following diagram is a generalized section made from these observations, showing the structure of this range. The section is supposed to extend from southwest to northeast, i. e., at right angles to the direction of the chain, L. V. being Livermore Valley and J. P. San Joaquin Plains.

1.



The range where crossed by the railroad is divided into two sub-ranges separated by Livermore Valley. Both of these sub-ranges, it will be seen, are composed wholly of crumpled strata, those of the western sub-range or Contra Costa hills being crumpled in the most extraordinary manner.

The strata throughout the railroad cut are entirely unchanged and very distinct, and their dip may be taken with the greatest ease and certainty: but unfortunately they consist mostly of thin bedded shales and sandstones destitute of fossils, and so similar in appearance that identification of individual strata would be impossible without the most careful and detailed examination. Only in one place did I find any fossils, and these were easily identified as Miocene Tertiary. On account of the infinite number and the sameness of the strata I found it impossible to identify, and therefore I have not attempted in the diagram to trace the individual strata through the successive folds. But the general structure of the range is, I am sure, truly represented in the section.

A glance at the section shows that the southwestern sub-range or that next the bay is far the more complex. We have here at least five anticlinals with corresponding synclinals, all in a distance of about six miles in a straight line. The angles of dip vary from 40° to 90°, the average being about 65° to 70°. This would make the actual length of the folded strata two and a half to three times the horizontal distance through the mountain. Now it is not only impossible to conceive of the origin of such structure except by horizontal mashing, but the amount

of horizontal mashing must have been enormous. Estimating in the usual way, i. e., taking the present length of the folded strata as the original length of the strata when horizontal, there must have been fifteen to eighteen miles of original sea-bottom crushed into six miles, with *corresponding* upswelling of the whole mass.* I say estimating in the usual way: for the *real* breadth of the original sea-bottom was probably considerably less, since as I shall show hereafter, the strata themselves are probably lengthened in the direction of the dip.

Nor is this particular section an exaggeration of the general structure of this range. On the contrary it is far less complex here than elsewhere. A glance at Whitney's map of Central California will show that the range is small and low at this part. This exceptional lowness is due primarily to the less horizontal mashing, and therefore less *upswelling*, and therefore *less complexity* of folding, and therefore less metamorphism, and therefore less hardness of the rocks, and therefore also *greater erosion* of this part. Whitney has nowhere attempted to give a general section of this very complex range, but in fig. 1 on p. 14 of vol. i, of the Geological Survey, he gives a section of a small portion of the Contra Costa hills farther north, which shows much more crushing than any portion of the range cut by the railroad.

The diagram section is supposed to be made at right angles to the general trend of the range, i. e., northeast and southwest. The folds are of course represented as striking in the direction of the range, and dipping in the direction of the section. This is very decidedly the average direction of the folds; but there is considerable variation to either side of this average direction. This shows that the horizontal or folding pressure came from several slightly different directions, perhaps consecutively. The same is clearly shown in the external features, also, of this very complex range; for the sub-ranges and ridges of which it is composed trend in many different directions.

But there is another minuter structure which I have observed in some of the strata, both of the Contra Costa and the Mt. Diablo sub-ranges, which demonstrates, in the completest manner, the mashing together horizontally and the extension vertically, even of the *constituent particles* of the stratified sediments.

* In my paper "On the great Lava flood of the northwest," this Journal, III, vol. vii, p. 167 and seq., I have stated, pp. 170 and 180, that under all circumstances, whether the surface be *uppushed* by horizontal mashing of sediments or *upbuilt* by the *outsqueezing* of melted matter, the increase of height would be the same, being measured by the amount of horizontal crushing. Prof. E. W. Hilgard, in his paper "On Mallet's theory of vulcanicity," Am. Jour., vol. vii, p. 535, note on p. 544, takes exception to this statement. He does not see "on what ground a simple *uplifting*, can be considered the precise mechanical equivalent of an *upbuilding* by eruption of liquid rock." I take this occasion to say that Prof. H. has entirely mistaken the point. It is not a question of *mechanical*, but of *geometrical* equivalence—not an equivalence of *force*, but an equivalence of *magnitude*.

I have already stated that the mountain mass lying between the Bay of San Francisco and the San Joaquin plains is divided, by the Amador and Livermore valleys, into two sub-ranges; the Contra Costa, overlooking the Bay, and the Mt. Diablo,* overlooking the plains. Both Cretaceous and Tertiary strata are found in the latter, although their distribution has not yet been thoroughly worked out; but the former consists wholly of Tertiary, principally Miocene. In both these sub-ranges seams of lignite of good quality have been found. Those found in the Cretaceous of Mt. Diablo have proved of great value and are extensively worked; but as yet nothing but very thin unprofitable seams have been found in the Contra Costa.

Several months ago I was asked to examine the *croppings* of some thin seams of lignite near the town of Hayward, which had been opened to a depth of 100 to 150 feet. The coal-bearing strata dip nearly perpendicularly and strike in the general direction of the range. The place examined was on the lowest foot hills of the Contra Costa, corresponding in position to *a* in the section, fig. 1.

While examining the mode of occurrence of this lignite, my attention was drawn, by the intelligent Superintendent of this mine, to certain slabs of shale in immediate contact with the seam, which were literally covered with small rounded flattened masses looking somewhat like flattened pebbles. In fact he supposed them to be pebbles or shingle which had fallen into fissures between the perpendicular strata. Examination, however, quickly convinced me that they were not pebbles nor extraneous matter of any kind, *but clay pellets or nodules in the original sediment which had been flattened by strong pressure in the formation of the mountain range.* Here then, I saw at once a means of determining the amount of mashing to which the sedimentary strata had been subjected in the process of mountain-making. I immediately commenced closer examination.

The nodules were all greatly flattened and nearly all greatly elongated. Their shape therefore were mostly flattened ellipsoids, though some were flattened discs. The flattened ellipsoids were nearly all set on end between the strata, i. e., with their long diameters vertical, though some varied considerably from this position to one side or the other, and a few were nearly horizontal. They were found in close contact with the seam on both sides, and some in the seam itself; and in such numbers that they covered the surface of the strata. When small and disc-shaped, or not much elongated, the surface of the over-clay blackened by contact with the coal presented a

* The term Mt. Diablo range is usually used in a wider sense for the whole range on the east side of the Bay, as distinguished from the Santa Cruz Mountains lying on the west side. I use the term here in a narrower sense to distinguish a subdivision of this range.

striking resemblance to impressions of the trunks of Lepidodendrids. In other cases when greatly elongated they looked like parallel flattened root-fibers. The material of the nodules was similar to that of the containing clay, unless perhaps a little finer.

A few months afterward, March, 1875, in company with a party of students and graduates of the University, I examined the coal mines of Mt. Diablo, and there also observed, in the roof of the seam, flattened nodules of sandstone often surrounded with a thin layer of coaly matter; but the sandstone was coarse and the nodules were imperfect. Subsequently Mr. Christy, an assistant in the chemical laboratory, who is now engaged in an examination of the coals of this coast, visited the same mines more extensively and brought me some very fine specimens of flattened elongated nodules. In these also I am assured the long diameters were in the direction of the dip.

Now, there cannot be the slightest doubt that these nodules were once *clay pellets*, of all sizes, from that of swan shot to that of hazel nuts, which existed in, and on the surface of, the original clay sediments, having been taken up from finer deposits rolled along by gentle currents and deposited along with coarser material, precisely as we find at the present day; and further, that their present shape is due wholly to subsequent pressure, precisely as in the case of the greenish elliptical spots found in cleaved slates, and described by Prof. Tyndall:* and, therefore, finally, that by means of their shape and position, as in the case of the greenish spots, it is quite possible to determine the amount of mashing together in one direction and the extension or upswelling in another, which the sedimentary mass has suffered since its deposition.

I take the case of the Hayward seam as the simplest because the strata are vertical. Taking three *equal* rectangular diameters of the original unmashed pellets, one in the direction of pressure, i. e., horizontal and at right angles to the strata; another also horizontal but in the direction of the strike, and the third in the direction of the dip or vertical, it is evident that the first would be *shortened*, the third would be *elongated*, while the second would, on the average, be *unaffected*, since extension of this diameter in some places must be compensated by shortening in contiguous places right or left. We may assume, therefore, that the elongation vertically is strictly correlated with the mashing or shortening horizontally, and the one is a measure of the other. Now I found by careful measurement of a great number of these nodules that the shortest diameter bears to the longest the ratios of 1 : 3, 1 : 4, 1 : 6, 1 : 9, and even 1 : 12 and 1 : 14. I believe a fair average would be about 1 : 6 or

* Phil. Mag., xii, 35, 1856.

1 : 9. Now as this ratio is the result of *both* compression in one direction and extension in another, it follows that either the compression or the extension would be expressed by the square roots of these ratios. Therefore there has been a crushing together of every 2·5 to 3 parts into 1 and a corresponding extension in another direction of every 1 part into 2·5 to 3. But since the short diameters were horizontal and the long diameters vertical, it is evident that throughout the whole squeezed mass every 2½ to 3 feet were crushed together horizontally into one foot, and every foot of vertical thickness was increased or swelled up to two and a half or three feet. This seems to have taken place principally after, by folding, the strata had taken a vertical position. Therefore by the pressure *the strata were thinned and extended vertically.* No allowance has hitherto been made for this change in the estimates of the original thickness of folded strata.

There are several thoughts suggested by the above which I think worthy of mention.

1. The position of the nodules, sometimes on the surface of the coal seam, sometimes half buried, and sometimes wholly buried in the coaly matter, clearly proves that at the time when the nodules were first rolled along and deposited there, *the coaly matter was in the condition of very soft semi-liquid peat.*

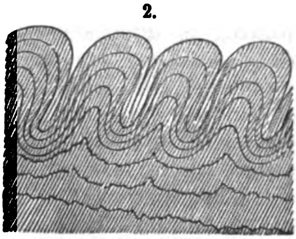
2. It is well known that slaty cleavage is produced by powerful pressure compressing the once plastic mass in one direction and extending it in another. The absence of slaty cleavage, under precisely these conditions, is evidently due, in the case under discussion, to the fact that the materials are unsuitable for the development of that structure, being *far too coarse.* If cleavage had been produced, however, *the planes of cleavage would have been parallel to the planes of stratification;* and, therefore, the structure would have been almost undistinguishable from, and liable to be mistaken for, a fine *lamination structure.*

Now, in many cases this parallelism actually occurs. On the foothills of the Sierra, especially about Snelling, Hornitos and Mariposa, are found fine clay slates beautifully fissile with their planes apparently perpendicular, but in reality dipping at a very high angle to the northeast, i. e., under the range. These are evidently true cleaved slates, and the very thin planes into which they easily split are true cleavage-planes and not lamination-planes. Yet I looked in vain for any stripe or other indication of stratification in any other direction. Also Whitney has shown (Geol. Surv., vol. i, p. 226), and I have myself observed, that these slates pass by insensible gradations into, and are even interstratified with, coarser materials, showing distinct stratification in the same direction, i. e., underdipping the

range at high angle. There can be no doubt, therefore, that *all* the strata of this foot-hill region, including the slates, underdip the range at high angle. Evidently, therefore, the cleavage planes of these slates are parallel to the stratification planes instead of cutting through them at high angle as is most common.

The diverse relation of the cleavage to the stratification planes I explain as follows: In a thick mass of very fine sediments mashed together horizontally it is evident that the surface and upper portions would first be thrown into one or more close folds by which the strata are brought into a nearly perpendicular position, and then these would be thinned and extended vertically by the pressure as already shown in the previous portion of this paper: but the *deeper portions* would be less and less folded, until, very deep, the folding would cease altogether and the mashing would be by *thickening* only and not by folding. I have rudely represented these facts in the diagram, fig. 2, in which the parallel, nearly vertical lines, represent the cleavage. In such a mass of horizontally squeezed fine sediments, therefore, the cleavage of the upper parts would be *parallel* with the strata while that of the lower parts would be *perpendicular* or nearly so to the strata. If, therefore, the upper parts only should be exposed by denudation we would have an example of cleavage parallel to the strata, and we might be in doubt whether to call the planes cleavage-planes or fine lamination-planes; but if greater denudation should expose the deeper portions we would have an example of cleavage-planes cutting through the lamination-planes at a high angle and therefore very distinct from them.

2.



3. It is evident from the above that in many cases the thickness of the strata as we now find them may be very different from that of the original sediments. In estimating the latter, therefore, we must make due allowance for the great thinning in some cases and thickening in others produced by pressure.

4. In my paper on the formation of the great features of the earth surface, already referred to, I have attributed mountain elevation to horizontal crushing. Prof. Dana,* however, thinks that, although the idea of plication is evidently included in my view, yet it ought to have a larger place than my words seem to give it—for the amount of elevation by plication is many times ("ten-fold") greater than by simple crushing.

* Am. Journ., III, v, 428.

Perhaps I ought to have been more explicit in my statement, but it seemed to me unnecessary, because on the assumption of a solid earth the amount of elevation would be the same, or nearly the same, whether, by the horizontal pressure, the strata be thrown into *closed folds* (as is most common in mountain chains) or only thickened without folding. If every two or three parts in horizontal extent of sediments be crushed into one part, there must be a corresponding thickening of the whole squeezed mass, and, therefore, a corresponding elevation of the surface, whether the strata be closely folded or only thickened without folding. In reality, doubtless, both occur in every case; close folding in the upper parts and thickening without folding in the deeper parts of the same squeezed mass. In fact it is impossible that the folding should occur above without a corresponding crushing and thickening below.

Again, I am satisfied that Prof. Dana greatly under-estimates the amount of elevation by simple mashing as compared with folding: 1st, because folding is a superficial phenomenon and therefore always exposed to view, while crushing without folding is deep seated and only rarely exposed; 2d, because folding is *always* revealed by stratification, while crushing is only *sometimes* revealed by cleavage, for this structure is only developed in *suitable* materials; and 3d, because even after folding, extension upward may take place by mashing together of the folds, as I have shown in the early part of this paper.

I have spoken thus far of *closed* folds. In *open* folds such as occur on the skirts of mountain chains where the horizontal crushing has not been sufficient to bring the folds together, the case might seem to be different; but even in these there must be a mashing of the strata below each anticlinal and proportioned to its height, unless we assume a hollow arch beneath, or else such an arch supported by a liquid, an assumption which is expressly set aside in my paper.

Berkeley, Oct. 11, 1875.

Art. XXXVIII.—*Brief Contributions to Zoology from the Museum of Yale College.* No. XXXVII.—*Description of Mancasellus brachyurus, a new fresh water Isopod;* by O. Harger.

The genus *Asellopsis* * was proposed by the writer for the reception of *Asellus tenax* Smith, on account of the absence of mandibular palpi. A second species of this interesting genus has lately been collected by Mr. Fred. Mather, in Rockbridge

* This Journal, III, vol. vii, p. 601, 1874.

Co., Virginia. Since the name *Asellopsis* proves to have been preoccupied I propose in its place *Mancasellus*,* retaining *M. tenax* as the typical species, while the new species may be called *M. brachyurus*, from the short caudal stylets. This species resembles *M. tenax*, described and figured in the Report of the United States Commissioner of Fish and Fisheries, Part II, Report for 1872–3, p. 659, plate I, fig. 3, differing principally from it in the following points: The lateral margins of the head are entire; the proximal segment of the caudal stylets is short, being but little longer than the third segment of the antennæ; the rami are also short, the inner being much stronger and somewhat longer than the outer; in the males the propodus of the first pair of legs is armed with a prominent acute tooth on the palmar margin near the base, and, in the appendages of the seventh segment, the terminal portion of the outer pair is smaller and less expanded externally than in *M. tenax*, and the distal segment of the internal ramus of the inner pair is but little swollen at the base, and approaches the form seen in *Asellus communis* Say. The largest specimen measures 16mm. in length exclusive of the antennæ and caudal stylets. The locality is worthy of mention as being on the Atlantic side of the Appalachian water-shed while *M. tenax* is yet known only from the Lakes.

Art. XXXIX.—*Professor Tyndall on Germs.*†

The author refers, in an introduction, to an inqury on the decomposition of vapors and the formation of actinic clouds by light, whereby he was led to experiment on the floating matter of the air. He refers to the experiments of Schwan, Schröder and Dusch, Schröder himself, to those of the illustrious French chemist Pasteur, to the reasoning of Lister and its experimental verification, regarding the filtering power of the lungs; from all of which he concluded, six years ago, that the power of developing life by the air, and its power of scattering light, would be found to go hand in hand. He thought the simple expedient of examining by means of a beam of light, while the eye was kept sensitive by darkness, the character of the medium in which their experiments were conducted, could not fail to be useful to workers in this field. But the method has not been much turned to account, and this year he thought it worth while to devote some time to the more complete demonstration of its utility.

* From *mancus*, maimed, and *Asellus*.

† On the Optical Deportment of the Atmosphere in reference to the Phenomena of Putrefaction and Infection. Abstract of a paper read before the Royal Society, January 13th, by Professor Tyndall, F.R.S. From Nature of Jan. 27 and Feb. 3.

He also wished to free his mind, and if possible the minds of others, from the uncertainty and confusion which now beset the doctrine of "spontaneous generation." Pasteur has pronounced it "a chimera," and expressed the undoubting conviction that, this being so, it is possible to remove parasitic diseases from the earth. To the medical profession, therefore, and through them to humanity at large, this question is one of the last importance. But the state of medical opinion regarding it is not satisfactory. In a recent number of the *British Medical Journal*, and in answer to the question, "in what way is contagium generated and communicated?" Messrs. Braidwood and Vacher reply that, notwithstanding "an almost incalculable amount of patient labor, the actual results obtained, especially as regards the manner of generation of contagium, have been most disappointing. Observers are even yet at variance whether these minute particles, whose discovery we have just noticed, and other disease germs, are always produced from like bodies previously existing, or whether they do not, under certain favorable conditions, spring into existence *de novo.*"

With a view to the possible diminution of the uncertainty thus described, the author submits, without further preface to the Royal Society, and especially to those who study the etiology of disease, a description of the mode of procedure followed in this inquiry, and the results to which it has led.

A number of chambers, or cases, were constructed, each with a glass front, its top, bottom, back and sides being of wood. At the back is a little door which opens and closes on hinges, while into the sides are inserted two panes of glass, facing each other. The top is perforated in the middle by a hole two inches in diameter, closed air-tight by a sheet of india-rubber. This sheet is pierced in the middle by a pin, and through the pin-hole is passed the shank of a long pipette ending above in a small funnel. A circular tin collar two inches in diameter and one inch and a half high, surrounds the pipette, the space between both being packed with cotton-wool moistened by glycerine. Thus the pipette, in moving up and down, is not only firmly clasped by the india-rubber, but it also passes through a stuffing box of sticky cotton-wool. The width of the aperture closed by the india-rubber secures the free lateral play of the lower end of the pipette. Into two other smaller apertures in the top of the case are inserted, air-tight, the open ends of two narrow tubes, intended to connect the interior space with the atmosphere. The tubes are bent several times up and down, so as to intercept and retain the particles carried by such feeble currents as changes of temperature might cause to set in between the outer and the inner air.

The bottom of the box is pierced with two rows, sometimes with a single row of apertures, in which are fixed, air-tight, large test-tubes, intended to contain the liquid to be exposed to the action of the moteless air.

On Sept. 10 the first case of this kind was closed. The passage of a concentrated beam across it through its two side windows

then showed the air within it to be laden with floating matter. On the 13th it was again examined. Before the beam entered, and after it quitted the case, its track was vivid in the air, but within the case it vanished. Three days of quiet sufficed to cause all the floating matter to be deposited on the sides and bottom, where it was retained by a coating of glycerine, with which the interior surface of the case had been purposely varnished. The test-tubes were then filled through the pipette, boiled for five minutes in a bath of brine or oil, and abandoned to the action of the moteless air. During ebullition aqueous vapor rose from the liquid into the chamber, where it was for the most part condensed, the uncondensed portion escaping, at a low temperature through the bent tubes at the top. Before the brine was removed little stoppers of cotton-wool were inserted in the bent tubes, lest the entrance of the air into the cooling chamber should at first be forcible enough to carry motes along with it. As soon, however, as the ambient temperature was assumed by the air within the case, the cotton-wool stoppers were removed.

We have here the oxygen, nitrogen, carbonic acid, ammonia, aqueous vapor, and all the other gaseous matters which mingle more or less with the air of a great city. We have them, moreover, "untortured" by calcination and unchanged even by filtration or manipulation of any kind. The question now before us is, can air thus retaining all its gaseous mixtures, but self-cleansed from mechanically suspended matter, produce putrefaction? To this question both the animal and vegetable worlds return a decided negative.

Among vegetables, experiments have been made with hay, turnips, tea, coffee, hops, repeated in various ways with both acid and alkaline infusions. Among animal substances are to be mentioned many experiments with urine; while beef, mutton, hare, rabbit, kidney, liver, fowl, pheasant, grouse, haddock, sole, salmon, cod, turbot, mullet, herring, whiting, eel, oyster have been all subjected to experiment.

The result is that infusions of these substances exposed to the common air of the Royal Institution laboratory, maintained at a temperature of from 60° to 70° Fahr., all fell into putrefaction in the course of from two to four days. No matter where the infusions were placed, they were infallibly smitten. The number of the tubes containing the infusions was multiplied till it reached six hundred, but not one of them escaped infection.

On the other hand, in no single instance did the air, which had been proved moteless by the searching beam, show itself to possess the least power of producing Bacterial life or the associated phenomena of putrefaction. The power of developing such life in atmospheric air, and the power of scattering light, are thus proved to be indissolubly united.

The sole condition necessary to cause these long-dormant infusions to swarm with active life is the access of the floating matter of the air. After having remained for four months as pellucid as

distilled water, the opening of the back-door of the protecting case, and the consequent admission of the mote-laden air, sufficed in three days to render the infusions putrid and full of life.

That such life arises from mechanically suspended particles is thus reduced to ocular demonstration. Let us inquire a little more closely into the character of the particles which produce the life. Pour Eau-de-Cologne into water, a white precipitate renders the liquid milky. Or, imitating Brücke, dissolve clean gum mastic in alcohol, and drop it into water, the mastic is precipitated and milkiness produced. If the solution be very strong the mastic separates in curds; but by gradually diluting the alcoholic solution we finally reach a point where the milkiness disappears, the liquid assuming, by reflected light, a bright cerulean hue. It is, in point of fact, the color of the sky, and is due to a similar cause, namely, the scattering of light by particles, small in comparison to the size of the waves of light.

When this liquid is examined by the highest microscopic power it seems as uniform as distilled water. The mastic particles, though innumerable, entirely elude the microscope. At right angles to a luminous beam passing among the particles they discharge perfectly polarised light. The optical deportment of the floating matter of the air proves it to be composed, in part, of particles of this excessively minute character. When the track of a parallel beam in dusty air is looked at horizontally through a Nicol's prism, in a direction perpendicular to the beam, the longer diagonal of the prism being vertical, a considerable portion of the light from the finer matter is extinguished. The coarser motes, on the other hand, flash out with greater force, because of the increased darkness of the space around them. It is among the finest ultra-microscopic particles that the author shows the matter potential as regards the development of Bacterial life is to be sought.

But though they are beyond the reach of the microscope, the existence of these particles, foreign to the atmosphere but floating in it, is as certain as if they could be felt between the fingers, or seen by the naked eye. Supposing them to augment in magnitude until they come, not only within range of the microscope, but within range of the unaided senses. Let it be assumed that our knowledge of them under these circumstances remains as defective as it is now—that we do not know whether they are germs, particles of dead organic dust, or particles of mineral matter. Suppose a vessel (say a flower-pot) to be at hand filled with nutritious earth, with which we mix our unknown particles; and that in forty-eight hours subsequently buds and blades of well-defined cresses and grasses appear above the soil. Suppose the experiment when repeated over and over again to yield the same unvarying result. What would be our conclusion? Should we regard those living plants as the products of dead dust or mineral particles; or should we regard them as the offspring of living seeds? The reply is unavoidable. We should undoubtedly con-

sider the experiment with the flower-pot as clearing up our pre-existing ignorance; we should regard the fact of their producing cresses and grasses as proof positive that the particles sown in the earth of the pot were the seeds of the plants which have grown from them. It would be simply monstrous to conclude that they had been "spontaneously generated."

This reasoning applies word for word to the development of *Bacteria* from that floating matter which the electric beam reveals in the air, and in the absence of which no Bacterial life has been generated. There seems no flaw in this reasoning; and it is so simple as to render it unlikely that the notion of Bacterial life developed from dead dust can ever gain currency among the members of a great scientific profession.

A novel mode of experiment has been here pursued, and it may be urged that the conditions laid down by other investigators in this field, which have led to different results, have not been strictly attended to. To secure accuracy in relation to these alleged results, the latest words of a writer on this question, who has influenced medical thought both in this country and in America, are quoted. "We know," he says, "that boiled turnip or hay-infusions exposed to ordinary air, exposed to filtered air, to calcined air, or shut off altogether from contact with air, are more or less prone to swarm with *Bacteria* and vibriones in the course of from two to six days." Who the "we" are who possess this knowledge is not stated. The author is certainly not among the number, though he has sought anxiously for knowledge of the kind. He thus tests the statements in succession.

And first, with regard to the filtered air. A group of twelve large test-tubes were caused to pass air-tight through a slab of wood. The wood was coated with cement, in which, while hot, a heated "propagating glass" resembling a large bell jar was imbedded. The air within the jar was pumped out several times, air filtered through a plug of cotton-wool being permitted to supply its place. The test-tubes contained infusions of hay, turnip, beef, and mutton —three of each—twelve in all. They are as clear and cloudless at the present moment as they were upon the day of their introduction; while twelve similar tubes, prepared at the same time in precisely the same way and exposed to the ordinary air, are clogged with mycelium, mould, and *Bacteria*.

With regard to the calcined air, a similar propagating glass was caused to cover twelve other tubes filled with the same infusions. The "glass" was exhausted and carefully filled with air which had passed through a red-hot platinum tube, containing a roll of red-hot platinum gauze. Tested by the searching beam, the calcined air was found quite free from floating matter. Not a speck has invaded the limpidity of the infusions exposed to it, while twelve similar tubes placed outside have fallen into rottenness.

The experiments with calcined air took another form. Six years ago it was found that to render the laboratory air free from

floating matter, it was only necessary to permit a platinum wire heated to whiteness to act upon it for a sufficient time. Shades, containing pear juice, damson juice, hay and turnip-juice, and water of yeast, were freed from their floating matter in this way. The infusions were subsequently boiled and permitted to remain in contact with the calcined air. They are quite unchanged to the present hour, while the same infusions exposed to common air became mouldy and rotten along ago.

It has been affirmed that turnip and hay-infusions rendered slightly alkaline are particularly prone to exhibit the phenomena of spontaneous generation. This was not found to be the case in the present investigation. Many such infusions have been prepared, and they have continued for months without sensible alteration.

Finally, with regard to infusions wholly withdrawn from air, a group of test-tubes, containing different infusions, was boiled under a bell-jar filled with filtered air, and from which the air was subsequently removed as far as possible by a good air-pump. They are now as pellucid as they were at the time of their preparation, more than two months ago, while a group of corresponding tubes exposed to the laboratory air have all fallen into rottenness.

There is still another form of experiment on which great weight has been laid—that of hermetically sealed tubes. On April 6 last, a discussion on the "Germ Theory of Disease" was opened before the Pathological Society of London. The meeting was attended by many distinguished medical men, some of whom were profoundly influenced by the arguments, and none of whom disputed the facts brought forward against the theory on that occasion. The following important summary of these was then given:— "With the view of settling these questions, therefore, we may carefully prepare an infusion from some animal tissue, be it muscle, kidney, or liver; we may place it in a flask whose neck is drawn out and narrowed in the blowpipe-flame, we may boil the fluid, seal the vessel during ebullition, and keeping it in a warm place, may await the result, as I have often done. After a variable time the previously heated fluid within the hermetically sealed flask swarms more or less plentifully with *Bacteria* and allied organisms."

Previous to reading this statement the author had operated upon tubes of hay and turnip-infusions, and upon twenty-one tubes of beef, mackerel, eel, oyster, oat-meal, malt, and potato, hermetically sealed while boiling, not by the blowpipe, but by the far more handy spirit-lamp flame. In no case was any appearance whatever of *Bacteria* or allied organisms observed. The perusal of the discussion just referred to caused the author to turn again to muscle, liver, and kidney, with a view of varying and multiplying the evidence. Fowl, pheasant, snipe, partridge, plover, wild duck, beef, mutton, heart, tongue, lungs, brains, sweetbread, tripe, the crystalline lens and vitreous humor of an ox, herring, haddock, mullet, codfish, sole, were all embraced in the experiments. There was neither mistake nor ambiguity about the result. One hun-

dred and thirty-nine of the flasks operated on were exhibited, and not one of this cloud of witnesses offers the least countenance to the assertion that liquids within flasks, boiled and hermetically sealed, swarm, subsequently, more or less plentifully with *Bacteria* and allied organisms.

The evidence furnished by this mass of experiments, that errors either of preparation or observation have been committed, is, it is submitted, very strong. But to err is human; and in an inquiry so difficult and fraught with such momentous issues, it is not error, but the persistence in error by any of us, for dialectic ends, that is to be deprecated. The auther shows by illustrations the risks of error run by himself. On Oct. 21 he opened the back-door of a case containing six test-tubes filled with an infusion of turnip which had remained perfectly clear for three weeks, while three days sufficed to crowd six similar tubes exposed to mote-laden air with *Bacteria*. With a small pipette he took specimens from the pellucid tubes, and placed them under the microscope. One of them yielded a field of Bacterial life, monstrous in its copiousness. For a long time he tried vainly to detect any source of error, and was perfectly prepared to abandon the unvarying inference from all the other experiments, and accept the result as a clear exception to what had previously appeared to be a general law. The cause of his perplexity was finally traced to the tiniest speck of an infusion containing *Bacteria*, which had clung by capillary attraction to the point of one of his pipettes.

Again, three tubes containing infusions of turnip, hay, and mutton, were boiled on Nov. 2 under a bell-jar containing air so carefully filtered that the most searching examination by a concentrated beam failed to reveal a particle of floating matter. At the present time every one of the tubes is thick with mycelium and covered with mould. Here surely we have a case of spontaneous generation. Let us look to its history.

After the air has been expelled from a boiling liquid it is difficult to continue the ebullition without "bumping." The liquid remains still for intervals, and then rises with sudden energy. It did so in the case now under consideration, and one of the tubes boiled over, the liquid over-spreading the resinous surface in which the bell-jar was imbedded, and on which, doubtless, germs had fallen. For three weeks the infusions had remained perfectly clear. At the end of this time, with a view of renewing the air of the jar, it was exhausted, and refilled by fresh air which had passed through a plug of cotton-wool. As the air entered, attention was attracted by two small spots of penicillium resting on the liquid which had boiled over. It was at once remarked that the experiment was a dangerous one, as the entering air would probably detach some of the spores of the penicillium and diffuse them in the bell-jar. This was, therefore, filled very slowly, so as to render the disturbance a minimum. Next day, however, a tuft of mycelium was observed at the bottom of one of the three tubes, namely that containing the hay-infusion. It has

by this time grown so as to fill a large portion of the tube. For nearly a month longer the two tubes containing the turnip and mutton-infusions maintained their transparency unimpaired. Late in December the mutton-infusion, which was in dangerous proximity to the outer mould, showed a tuft upon its surface. The beef-infusion continued bright and clear for nearly a fortnight longer. The recent cold weather caused me to add a third gas-stove to the two which had previously warmed the room in which the experiments are conducted. The warmth of this stove played upon one side of the bell-jar: and on the day after the lighting of the stove, the beef-infusion gave birth to a tuft of mycelium. In this case the small spots of penicillium might have readily escaped attention; and had they done so we should have had three cases of "spontaneous generation" far more striking than many that have been adduced.

In further illustration of the dangers incurred in this field of inquiry the author refers to the excellent paper of Dr. Roberts on Biogenesis, in the "Philosophical Transactions" for 1874. Dr. Roberts fills the bulb of an ordinary pipette to about two-thirds of its capacity with the infusion to be examined. In the neck of the pipette he places a plug of dry cotton-wool. He then hermetically seals the neck and dips the bulb into boiling water or hot oil, where he permits it to remain for the requisite time. Here we have no disturbance from ebullition, and no loss by evaporation. The bulb is removed from the hot water and permitted to cool. The sealed end of the neck is then filed off, the cotton-wool alone interposing between the infusion and the atmosphere.

The arrangement is beautiful, but it has one weak point. Cotton-wool free from germs is not to be found, and the plug employed by Dr. Roberts infallibly contained them. In the gentle movement of the air to and fro as the temperature changed, or by any shock, jar, or motion to which the pipette might be subjected, we have certainly a cause sufficient to detach a germ now and then from the cotton-wool which would fall into the infusion and produce its effect. Probably, also, condensation occurred at times in the neck of the pipette; the water of condensation carrying back from the cotton-wool the seeds of life. The fact of fertilization being so rare as Dr. Roberts found it to be is a proof of the care with which his experiments were conducted. But he did find cases of fertillization after prolonged exposure to the boiling temperature; and this caused him to come to the conclusion that under certain rare conditions spontaneous generation may occur. He also found that an alkalised hay-infusion was so difficult to sterilise that it was capable of withstanding the boiling temperasure for hours without losing its power of generating life. The most careful experiments have been made with this infusion. Dr. Roberts is certainly correct in assigning to it superior nutritive power. But in the present inquiry five minutes boiling sufficed to completely sterilise the infusion.

Summing up this portion of his inquiry, the author remarks that he will hardly be charged with any desire to limit the power and potency of matter. But holding the notions he does upon this point, it is all the more incumbent on him to affirm that as far as inquiry has hitherto penetrated, life has never been proved to appear independently of antecedent life.

Though the author had no reason to doubt the general diffusion of germs in the atmosphere, he thought it desirable to place the point beyond question. At Down, Mr. Darwin, Mr. Francis Darwin; at High Elms, Sir John Lubbock; at Sherwood, near Tunbridge Wells, Mr. Siemens; at Pembroke Lodge, Richmond Park, Mr. Rollo Russell; at Heathfield Park, Messrs. Hamilton; at Greenwich Hospital, Mr. Hirst; at Kew, Dr. Hooker; and at the Crystal Palace, Mr. Price, kindly took charge of infusions, every one of which became charged with organisms. To obtain more definite insight regarding the diffusion of atmospheric germs, a square wooden tray was pierced with 100 holes, into each of which was dropped a short test-tube. On Oct. 23, thirty of these tubes were filled with an infusion of hay, thirty-five with an infusion of turnip, and thirty-five with an infusion of beef. The tubes, with their infusions, had been previously boiled, ten at a time, in an oil-bath. One hundred circles were marked on paper so as to form a map of the tray, and every day the state of each tube was registered upon the corresponding circle. In the following description the term "cloudy" is used to denote the first stage of turbidity; distinct but not strong. The term "muddy" is used to denote thick turbidity.

One tube of the 100 was first singled out and rendered muddy. It belonged to the beef group, and it was a whole day in advance of all the other tubes. The progress of putrefaction was first registered on Oct. 26; the "map" then taken may be thus described:

Hay.—Of the thirty specimens exposed one had become "muddy"—the seventh in the middle row reckoning from the side of the tray nearest the stove. Six tubes remained perfectly clear between this muddy one and the stove, proving that differences of warmth may be overridden by other causes. Every one of the other tubes containing the hay infusion showed spots of mould upon the clear liquid.

Turnip.—Four of the thirty-five tubes were very muddy, two of them being in the row next the stove, one four rows distant, and the remaining one seven rows away. Besides these six tubes had become clouded. There was no mould on any of the tubes.

Beef.—One tube of the thirty-five was quite muddy, in the seventh row from the stove. There were three cloudy tubes, while seven of them bore spots of mould.

As a general rule organic infusions exposed to the air during the autumn remained for two days or more perfectly clear. Doubtless from the first germs fell into them, but they required time to be hatched. This period of clearness may be called the "period of latency," and indeed it exactly corresponds with what

is understood by this term in medicine. Toward the end of the period of latency, the fall into a state of disease is comparatively sudden; the infusion passing from perfect clearness to cloudiness more or less dense in a few hours.

Thus the tube placed in Mr. Darwin's possession was clear at 8.30 A. M. on Oct. 19, and cloudy at 4.30 P. M. Seven hours, moreover, after the first record of our tray of tubes, a marked change had occurred. It may be thus described:—Instead of one, eight of the tubes containing hay-infusion had fallen into uniform muddiness. Twenty of these had produced Bacterial slime, which had fallen to the bottom, every tube containing the slime being covered by mould. Three tubes only remained clear, but with mould upon their surfaces. The muddy turnip-tubes had increased from four to ten; seven tubes were clouded, while eighteen of them remained clear, with here and there a speck of mould on the surface. Of the beef, six were cloudy and one thickly muddy, while spots of mould had formed on the majority of the remaining tubes. Fifteen hours subsequent to this observation, viz. on the morning of Oct. 27, all the tubes containing hay-infusion were smitten, though in different degrees, some of them being much more turbid than others. Of the turnip-tubes, three only remained unsmitten, and two of these had mould upon their surfaces. Only one of the thirty-five beef-infusions remained intact. A change of occupancy, moreover, had occurred in the tube which first gave way. Its muddiness remained gray for a day and a half, then it changed to bright yellow green, and it maintained this color to the end. On the 27th every tube of the hundred was smitten, the majority with uniform turbidity; some, however, with mould above and slime below, the intermediate liquid being tolerably clear. The whole process bore striking resemblance to the propagation of a plague among a population, the attacks being successive and of different degrees of virulence.

From the irregular manner in which the tubes are attacked, we may infer that, as regards *quantity*, the distribution of the germs in the air is not uniform. The singling out, moreover, of one tube of the hundred by the particular *Bacteria* that develop a green pigment, shows that, as regards *quality*, the distribution is not uniform. The same absence of uniformity was manifested in the struggle for existence between the *Bacteria* and the penicillium. In some tubes the former were triumphant; in other tubes of the same infusion the latter was triumphant. It would seem also as if a want of uniformity as regards *vital vigor* prevailed. With the self-same infusion the motions of the *Bacteria* in some tubes were exceedingly languid, while in other tubes the motions resembled a rain of projectiles, being so rapid and violent as to be followed with difficulty by the eye. Reflecting on the whole of this, the author concludes that the germs float through the atmosphere in groups or clouds, with spaces more sparsely filled between them. The touching of a nutritive fluid by a Bacterial cloud would naturally have a different effect from the touching of

it by the interspace between two clouds. But as in the case of a mottled sky, the various portions of the landscape are successively visited by shade, so, in the long run, are the various tubes of our tray touched by the Bacterial clouds, the final fertilization or infection of them all being the consequence. The author connects these results with the experiments of Pasteur on the non-continuity of the cause of so-called spontaneous generation, and with other experiments of his own.*

On the 9th of November a second tray containing one hundred tubes filled with an infusion of mutton was exposed to the air. On the morning of the 11th six of the ten nearest the stove had given way to putrefaction. Three of the rows most distant from the stove had yielded, while here and there over the tray particular tubes were singled out and smitten by the infection. Of the whole tray of one hundred tubes, twenty-seven were either muddy or cloudy on the 11th. Thus, doubtless, in a contagious atmosphere, are individuals successively struck down. On the 12th all the tubes had given way, but the differences in their contents were extraordinary. All of them contained *Bacteria*, some few, others in swarms. In some tubes they were slow and sickly in their motions, in some apparently dead, while in others they darted about with rampant vigor. These differences are to be referred to changes in the germinal matter, for the same infusion was presented everywhere to the air. Here also we have a picture of what occurs during an epidemic, the difference in number and energy of the Bacterial swarms resembling the varying intensity of the disease. It becomes obvious from these experiments that of two individuals of the same population, exposed to a contagious atmosphere, the one may be severely, the other lightly attacked, though the two individuals may be as identical as regards susceptibility as two samples of one and the same mutton infusion.

The author traces still further the parallelism of these actions with the progress of infectious disease. The *Times* of January 17th contained a letter on Typhoid Fever signed "M.D.," in which occurs the following remarkable statement:—"In one part of it (Edinburgh), congregated together and inhabited by the lowest of the population, there are, according to the Corporation return for 1874, no less than 14,319 houses or dwellings—many under one roof, on the 'flat' system—in which there are no house connections whatever with the street sewers, and, consequently, no water-closets. To this day, therefore, all the excrementitious and other refuse of the inhabitants is collected

* In hospital practice the opening of a wound during the passage of a Bacterial cloud would have an effect very different from the opening of it in the interspace between two clouds. Certain caprices in the behavior of dressed wounds may possibly be accounted for in this way. Under the heading "Nothing new under the Sun," Prof. Huxley has just sent me the following remarkable extract:—"Uebrigens kann man sich die in der Atmosphäre schwimmenden Thierchen wie Wolken denken, mit denen ganz leere Luftmassen, ja ganze Tage völlig reinen Luftverhältnisse wechseln." (Ehrenberg, "Infusions Thierchen," 1838, p. 525.) The coincidence of phraseology is surprising, for I knew nothing of Ehrenberg's conception. My "clouds," however, are but small miniatures of his.

in pails or pans, and remains in their midst, generally in a partitioned-off corner of the living room, until the next day, when it is taken down to the streets and emptied into the Corporation carts. Drunken and vicious though the population be, herded together like sheep, and with the filth collected and kept for twenty-four hours in their very midst, it is a remarkable fact that typhoid fever and diphtheria are simply unknown in these wretched hovels."

This case has its analogue in the following experiment, which is representative of a class. On Nov. 30 a quantity of animal refuse, embracing beef, fish, rabbit, hare, was placed in two large test-tubes opening into a protecting chamber containing six tubes. On Dec. 13, when the refuse was in a state of noisome putrefaction, infusions of whiting, turnip, beef and mutton were placed in the other four tubes. They were boiled and abandoned to the action of the foul "sewer gas" emitted by their two putrid companions. On Christmas-day the four infusions were limpid. The end of the pipette was then dipped into one of the putrid tubes, and a quantity of matter comparable in smallness to the pock-lymph held on the point of a lancet was transferred to the turnip. Its clearness was not sensibly affected at the time; but on the 26th it was turbid throughout. On the 27th a speck from the infected turnip was transferred to the whiting; on the 28th disease had taken entire possession of the whiting. To the present hour the beef and mutton tubes remain as limpid as distilled water. Just as in the case of the living men and women in Edinburgh, no amount of fetid gas had the power of propagating the plague, so long as the organisms which constitute the true contagium did not gain access to the infusions.

The universal prevalence of the germinal matter of *Bacteria* in water has been demonstrated with the utmost evidence by the experiments by Dr. Burdon Sanderson. But the germs in water are in a very different condition, as regards readiness for development, from those in air. In water they are thoroughly wetted, and ready, under the proper conditions, to pass rapidly into the finished organisms. In air they are more or less desiccated, and require a period of preparation more or less long to bring them up to the starting-point of the water-germs. The rapidity of development in an infusion infected by either a speck of liquid containing *Bacteria* or a drop of water is extraordinary. On Jan. 4 a thread of glass almost as fine as a hair was dipped into a cloudy turnip infusion, and the tip only of the glass fiber was introduced into a large test-tube containing an infusion of red mullet. Twelve hours subsequently the perfectly pellucid liquid was cloudy throughout. A second test-tube containing the same infusion was infected with a single drop of the distilled water furnished by Messrs. Hopkin and Williams; twelve hours also sufficed to cloud the infusion thus treated. Precisely the same experiments were made with herring with the same result. At this season of the year several days' exposure to the air are

to produce so great an effect. On Dec. 31 a strong turnip-infusion was prepared by digesting thin slices in distilled water at a temperature of 120° F. The infusion was divided between four large test-tubes, in one of which it was left unboiled, in another boiled for five minutes, in the two remaining ones boiled, and after cooling infected with one drop of beef-infusion containing *Bacteria*. In twenty-four hours the unboiled tube and the two infected ones were cloudy, the unboiled tube being the most turbid of the three. The infusion here was peculiarly limpid after digestion; for turnip it was quite exceptional, and no amount of searching with the microscope could reveal in it at first the trace of a living Bacterium; still germs were there which, suitably nourished, passed in a single day into Bacterial swarms without number. Five days have not sufficed to produce an effect approximately equal to this in the boiled tube, which was uninfected but exposed to the common laboratory air.

There cannot, moreover, be a doubt that the germs in the air differ widely among themselves as regards *preparedness* for development. Some are fresh, others old; some are dry, others moist. Infected by such germs the same infusion would require different lengths of time to develop Bacterial life. This remark applies to and explains the different degrees of rapidity with which epidemic disease acts upon different people. In some the hatching-period, if it may be called such, is long, in some short, the differences depending upon the different degrees of preparedness of the contagium.

The author refers with particular satisfaction to the untiring patience, the admirable mechanical skill, the veracity in thought, word, and deed, displayed throughout this first section of a large and complicated inquiry by his assistant, Mr. John Cottrell, who was zealously aided by his junior colleague, Mr. Frank Valter.

NOTE. *Jan.* 31.—The notion that the author limited himself to temperatures of 60° and 70° Fahr. is an entire misconception. But more of this anon.

ART. XL.—*Discovery of a new Planet*; by C. H. F. PETERS. (From a letter to one of the Editors, dated Litchfield Observatory of Hamilton College, Clinton, N. Y., Feb. 26, 1876.)

A new planet, eleventh magnitude, was first seen here on the night of the 20th inst., and, after several days of bad weather, again observed on the following nights. The positions are as follows:

1876.	Ham. Col. m. t.	α(160)	δ(160)	
Feb. 20,	15^h —^{m} —^{s}	10^h 20^m 59^s	+14° 14.'1	
" 24,	12 25 41	10 17 26·8	+14 28 45	(12 comp.)
" 25,	11 46 11	10 16 33·92	+14 32 26·0	(15 comp.)

On the first night only an approximate observation was made. For the second night the comparison star still needs determination by means of the meridian circle.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On a Crystallized Hydrate of Hydrochloric acid.*—Pierre and Puchot have observed that, when a saturated solution of hydrochloric acid gas is cooled to $-21°$ or $-22°$ C., the dry gas being passed continuously into the liquid, after a few minutes the temperature rises to $-18°$ and an abundant crystallization begins, during which the temperature remains constant at $-18°$. Before the crystallization commences, there is always observed this lowering of 3° or 4° in temperature, which is a phenomenon analogous to sursaturation. A synthetic experiment showed that, to produce the crystals, the water absorbed about its own weight of the gas; and hence showed that the probable formula was $HCl.(H_2O)_2$. In the air the crystals decompose readily, giving off dense fumes of hydrogen chloride. In a flask, kept near 0°, they slowly melt, the temperature remaining at $-18°$; in one experiment 115 grams of the crystals required an hour and a quarter to melt. Water dissolves them readily. Since they sink in the solution where they are formed, they must be denser than it. They set free the gas in melting, and hence must contain more of it than the mother liquors. In the analysis, a known weight of the drained crystals was treated with a definite quantity of distilled water, in amount sufficient to prevent the evolution of gas. The chlorine was then determined in the solution, and from this the ratio between the HCl and the H_2O could be calculated. In the first two determinations, the ratio was 1:2·19; in the second it was 1:2·085 and 1:2·075. Hence the authors conclude upon the formula $HCl.(H_2O)_2$; this is the best defined hydrate of hydrochloric acid yet observed. A mixture of snow two parts and hydrochloric acid one part gives a temperature of $-32°$C.; or of $-35°$ if the materials are previously cooled.—*C. R.*, lxxxii, 45, Jan. 1876. G. F. B.

2. *On the Decomposition of Water by Platinum.*—Sainte Claire Deville and Debray state that if potassium cyanide be heated in a glass tube to 500° or 600°, in the vicinity of a boat full of warm water, the tube having been previously exhausted, the pressure rises to half an atmosphere, and remains constant for hours; but if, before the operation, some platinum sponge has been mixed with the cyanide, hydrogen is abundantly evolved, and a potassio-platinum cyanide is formed. This hydrogen contains from 4½ to 12 per cent of carbonous oxide, produced according to the following reaction.

$$(KCN)_2+(H_2O)_4=K_2CO_3+(NH_3)_2+H_2+CO$$

If the principal reaction in the foregoing experiment be written—

$$(KCy)_4+(H_2O)_2=PtCy_2(KCy)_2+(KOH)_2+H_2$$

it would appear as if the platinum decomposed water under the influence of the potassic cyanide. But the authors show from thermal considerations that the potassium hydrate formed is really the important product; that in its formation the greatest amount of

heat is developed, and hence it is really the determinant of the reaction. From the same causes, a boiling concentrated solution of potassium cyanide attacks platinum, setting free hydrogen; an experiment the authors recommend as a convenient one to illustrate the principles of thermo-chemistry upon the lecture-table. So also a boiling solution of mercuric cyanide does not attack platinum unless potassium cyanide be present; then the mercury at once separates.—*C. R.*, lxxxii, 241, Jan. 1876. G. F. B.

3. *On a New Compound of Sulphur and Oxygen.*—For many years it has been known that the action of sulphur on sulphuric oxide or on disulphuric acid produces an intense blue color. R. Weber has successfully investigated the cause of this color, and has shown that it is due to a new oxide of sulphur which he has isolated. To prepare it, a portion of sulphuric oxide is prepared, containing some sulphuric acid, and into this is thrown, in small portions, carefully dried flowers of sulphur. At the instant of contact the sulphur is converted into dark blue liquid drops which sink to the bottom of the liquid and there solidify. Care should be taken to keep the temperature at 15° C., since below this point the whole liquid solidifies, and above it the blue body decomposes. After the operation, the excess of liquid is poured off, the blue crystalline crusts are drained and the excess of sulphuric oxide driven off at a temperature not exceeding blood heat. Bluish green crusts are thus obtained, which are very friable and which have a structure similar to malachite. They decompose without fusion slowly at ordinary temperatures, more rapidly on heating, evolving sulphurous oxide and leaving sulphur behind. In a cool place the decomposition is so slow that the substance may readily be weighed for analysis. Moist air decomposes it rapidly and it hisses when thrown into water. Alcohol and ether also decompose it, and set free sulphur. A mean of five closely accordant analyses showed that it contained 57·12 per cent of sulphur; thus giving it the formula S_2O_3. The author names it sulphur sesquioxide or dithionic oxide. No compounds of it have yet been made. Selenium gives an analogous compound having the formula $SeSO_3$. It is dirty-green in mass, yellow in powder.—*Pogg. Ann.*, clvi, 531 Dec., 1875.

G. F. B.

4. *On the Purification of Carbon disulphide.*—Friedberg proposes to effect the final purification of carbon disulphide by treating it with fuming nitric acid. The crude disulphide is first purified by repeated distillation with a vegetable fat, such as palm oil, and is then treated with the acid and frequently agitated. After twenty-four hours two layers are observed, nearly of the same color, the red vapors of the acid having been absorbed by the CS_2. If water be added, the disulphide becomes reddish violet, and this separated from the acid, washed, and gently heated, gives up pure disulphide in the distillate, while the violet-colored solution of the disulphide remains behind, and is not broken up except at a higher temperature. The colorless distillate, washed with water dried and distilled, is chemically pure. The author is investigating the solvent

power of this substance for gaseous substances.—*Ber. Berl. Chem. Ges.*, viii, 1616, Jan. 1876. G. F. B.

5. *The New Metal Gallium.*—In the session of the French Academy on September 20, the Secretary opened a sealed note deposited by LECOQ DE BOISBAUDRAN, the first paragraph of which reads thus:—"Day before yesterday, on Friday the 27th of August, 1875, between three and four o'clock in the afternoon, I obtained indications of the probable existence of a new simple body among the products of the chemical examination of a blende coming from the mine of Pierrefitte, valley of Argeles, Pyrenees." The evidence relied on to prove this discovery, a part of which evidence was given in the sealed note and another part in a note read at the same meeting, is: (1) the oxide (or perhaps a basic salt) is precipitated slowly by metallic zinc in a solution containing chlorides and sulphates; (2) its salts are easily precipitated by barium carbonate in the cold; and (3) it gives a spectrum showing two violet lines of wave lengths 417 and 404 respectively. In all its other chemical reactions, it closely resembles zinc; though in the precipitations it has always the preference when these are incomplete. To the metal thus indicated, Lecoq de Boisbaudran gave the name *Gallium.* In a more recent paper he gives additional facts regarding the new metal, which he has been able to free almost entirely from zinc. From it he has prepared a salt which he believes to be gallium-alum. It is soluble in cold water, but is decomposed on heating, unless acetic acid be present. It crystallizes in octahedrons and cubes, presenting the appearance of common alum, especially under the microscope; the crystals do not polarize light. Placed in a super-saturated solution of ammonio-aluminum alum, they act as nuclei and begin to grow. Treated with ammonia, a part only of the oxide is thrown down. In ammoniacal solution, the metal is precipitated by electrolysis on the negative electrode. In the first trial 1·6 milligrams were deposited in 4½ hours; in the second, 3·4 milligrams was deposited in 5 hours 40 minutes. (This sample was submitted to the Academy.) The metal adhered strongly to the platinum on which it was deposited. When burnished its surface is brilliant, and has a color between silver and platinum. With a feeble current, the metal comes down frosted and crystalline. It does not decompose water at ordinary temperatures, and tarnishes slowly in the open air. With HCl, it evolves hydrogen. On the evidence of the alum, he fixes the formula of the oxide as Ga_2O_3, and assigns the metal to the aluminum group. In a subsequent note, the author gives the results of the more accurate measurement of the wave-lengths of the two lines of the gallium spectrum, α and β. A concentrated solution of the chloride gave only the two lines at first observed, of wave-lengths 417 and 403·1, the former being the stronger.—*C. R.*, lxxxi, 493 (Sept.) 1100, (Dec. 1875); lxxxii, 168, Jan. 1876. G. F. B.

6. *Conductibility of Gases.*—M. A. WINKELMANN has measured the conductibility of gases for heat by an apparatus like that of Stephan, except that a peculiar manometer and method of

closure is used. The apparatus consists of a brass cylinder serving as an air thermometer enclosed in a second concentric cylinder. The top of the inner cylinder may be unscrewed and it carries a conical cavity in which is placed a rubber cork with a hole through it. A glass tube passes through this hole and a metallic cap screwed on below the rubber presses it against the glass. A similar closure carries the tube through the outer cylinder. The latter is connected with a mercury pump. A comparison of the time and variations of the pressure when the outer cylinder was immersed in ice-water gave the following coefficients of conductibility:

Name.	Conduct.
Air	·0000525
Hydrogen	·0003324
Carbonic Acid	·0000317
Ethyl	·0000414
Marsh Gas	·0000647
Nitric Oxide	·0000460
Carbonic Oxide	·0000510
Oxygen	·0000563
Nitrous Oxide	·0000363
Nitrogen	·0000524

—*Pogg. Ann.* clvi, 497. E. C. P.

7. *Thermal Properties of Liquids.*—M. PICTET has applied the mechanical theory of heat to the study of volatile liquids, making use of the experiments of Regnault, and deduces the following simple relations between their latent heats, atomic weight and vapor tension:

(1.) The cohesion of all liquids is constant.

(2.) The differential coefficient of the Naperian logarithm of the tension divided by the temperature is constant for all liquids when referred to the same pressure and temperature.

(3.) The latent heat of all liquids referred to the same pressure, multiplied by the atomic weight referred to the same temperature, gives a constant product.

(4.) For all liquids the difference of the internal latent heats at any two temperatures, multiplied by the atomic weight is a constant number.

It thus appears that quantities at first sight wholly independent are really connected by very simple relations, which dispense with long empirical formulas based on observations more or less open to criticism.

Furthermore, admitting the law of Dulong and Petit for specific heats, we can further say that the latent heat of all liquids are multiples of their specific heats.—*Bibl. Univ.*, ccxvii, 66.

E. C. P.

8. *Dependence of Electrical Resistance on the Motion of the Conductor.*—M. EDLUND has brought to bear a new argument in favor of his theory of electricity, by showing that the resistance of a conductor is affected by its motion. Water is allowed to

flow through a long tube having three electrodes of gold wire admitted at its ends and center. A battery of two Daniell's cells has one terminal connected with the center electrode, and the other with two of the terminals of a delicate differential astatic galvanometer. The two end electrodes are connected with the other terminals of the galvanometer. The current from the battery divides, and half passes through the tube in each direction. By suitably varying the resistance, the galvanometer needle will now be at rest. When the water is caused to flow through the tube, however, the resistance in one direction will be increased, and that in the other diminished, since, according to Edlund's theory the current is proportional to the amount of ether flowing through a given section per second. Accordingly the needle should deviate, as, in fact, it does. To eliminate the effects of polarization, the current was inverted without changing the result. That the deviations may be regular, it is essential that the liquid should have a great resistance and the amount of deviation is almost independent of this resistance. Two series of observations were made, one with distilled water, the other with alcohol and water, and gave similar results. A third series with aqueduct water gave the same result. Finally, equal currents were sent in opposite directions through the pipe, when they produced no effect on the needle, but as soon as the liquid was set in motion a deviation was always obtained indicating that the resistance was greater in one direction than in the other. These two methods of observation lead to the same result, foreseen by the theory of Edlund, namely, that the galvanic resistance diminishes if the conductor moves in the same direction as the galvanic current and increases on the contrary if the other two currents move in opposite directions.—*Royal Swedish Acad.*, III., *No.* 11, *Phil. Mag.*, l, 89. E. C. P.

9. *Electric Spark with large Batteries.*—Messrs. Warren de la Rue and H. W. Muller presented to the Royal Society at a recent meeting a paper having the following title: On the length of the Spark from a Battery of 600, 1200, 1800 and 2400 rod-chloride of Silver, and some Phenomena attending the discharge of 5640 cells. A year ago some experiments on the stratification of the discharge in vacuo of a battery of 1080 cells were described. This battery has now been augmented to 5640 cells, and two other batteries will soon be added making 9120 cells. Having completed 2400 cells and charged them up in a single day, they were exactly in the same condition as to electro-motive force and internal resistance, consequently they afforded the means of testing the truth of the law of the length of the spark in a manner more efficacious than had hitherto been obtained, the more especially as by the use of paraffin corks and other precautions we had obtained an excellent insulation. A discharger with a micrometer-screw was constructed by which the length of spark could be measured to ·001 of an inch, or by estimation to one-tenth of that quantity. In making measurements the terminals were separated

to a greater distance than the anticipated striking-distance and gradually approached until the spark passed. The discharger was then detached from the battery, and after reading the scale, connected with a separate battery of 10 cells with a detector-galvanometer in circuit. The terminals were again approached until the motion of the galvanometer indicated contact between them. The scale was again read, and the change in reading gave the required length of spark. With 600, 1200, 1800 and 2400 cells the striking-distances were found to be ·0033, ·0130, ·0345 and ·0535 inches. These numbers are nearly proportional to the square of the number of cells, which would give the distances ·0033, ·0132, ·0297, ·0528. The length of spark is much influenced by the form of the terminal. Generally a copper-pointed plane was employed and the current reversed 352 times per second by a revolving commutator, or a double key discharger.

When the point was negative, a glow in form like a paraboloid was seen surrounding it long before the spark passed, and as the distance was diminished gradually extending to the positive terminal. With 1800 cells the glow was seen at a distance of ·0545 and with 2400 cells at a distance of ·0865 inches. Moreover when the disc was positive it became covered with a peach-like bloom which became stronger in the center as the terminals were approached, giving rise to Newton's rings. This effect was next studied with the whole series of 5640 cells. The glow was now visible at 1·073 in. and the spark passed at ·139. Replacing the flat disc by one that was slightly convex the glow occurred at 1·124 in. and the spark at ·140. Reversing, the current gave sparks of ·154 and ·164 in.

To ascertain whether a current really passed when the glow appeared, vacuum-tubes were interposed when they were illuminated even before the glow appeared. Of course the striking distance was in this case shortened. With a hydrogen tube having a resistance of 190,000 ohms the glow occurred at ·939 and the spark at ·092 inches. A 31-inch tube was brilliantly illuminated when interposed between one terminal and the battery, when the terminals were separated to the extreme range of the discharger or 1·2 in. and before any glow was visible at the negative electrode. Later a current was obtained with the negative point 5·1 in. distant from a positive plate 6 in. in diameter.

Considerable difficulty was experienced in measuring the resistance of the tubes, and it soon appeared that this resistance rapidly increased as the current passed. After a time, however, they recovered their original resistance. Ultimately it was found to be better to discard the indications of the galvanometer and to rely solely on the appearance of a luminosity in the tubes placed on one side of Wheatstone's bridge as soon as the insertion of a balancing resistance was made in the other. A curious conclusion is derived from the law that the length of spark is proportional to the square of the number of cells, if it proves to be correct. One cell would give a spark about ·00000001 in. long while a hundred

thousand which come within the limit of experimental possibility would give a spark about 92 inches long. Probably a million would never be made but they should give a spark 9166 inches or 764 feet long.—*Nature*, xiii, 277. E. C. P.

10. *Acoustics.* Letter to the editors by Professor A. M. Mayer, dated Stevens Institute of Technology, Hoboken, New Jersey, March 17th, 1876.—Gentlemen: Having in hand researches whose completion will occupy several months, I desire to place on record my invention of the two following methods of research. The first is a plan for *the determination of the relative intensities of sounds of the same pitch.* The second is *a method of determining the direction of sounds.* I request the privilege of being permitted first to attempt to develop these ideas after I have finished the original work which at present occupies all my leisure.

First method. A loose membrane, or a slip of gold or aluminium foil, is placed anywhere between the centers of origin of two sounds of the same pitch. The plane of this membrane is at right angles to the line connecting these sonorous centers. If both sides of the membrane are simultaneously acted on by sonorous vibrations of the same phase and of equal intensity, the membrane will remain at rest. The above condition is thus attained. Attach to the center of the membrane a short delicate glass thread whose end can be observed through a microscope, or, place a reflecting metallic film on the central part of the membrane so that one can observe the motion of a beam of light reflected therefrom. If we place, at hazard, the membrane between the sonorous centers it is probable that it will be set in vibration. Now if it is moved from its position its vibrations will either increase or decrease in amplitude. Move it in the direction that causes the amplitude of the vibrations to decrease, and until the vibrations have a minimum of swing. The membrane is now in a plane where the phases of vibration are the same but of *unequal* intensity. The membrane is now moved one-half wave-length either from or toward one of the sonorous centers and is thus brought into another plane of minimum vibration. Thus move the membrane until it is brought into that plane where vibrations of the membrane are either entirely destroyed or have their least amplitude. If the membrane vibrates, then move it and the source of one of the sounds so that they both approach to or recede from the other sonorous center always by the same quantity. This is accomplished by moving a board to which is attached the membrane and one of the sources of sound. By the last adjustment we can soon reach a plane where the membrane remains at rest and where the intensities of the two sonorous vibrations are equal. It appears that I have thus devised a *phonometer* which is analogous to the photometer of Bunsen.

The above method appears to me preferable to the phonometer I described in this Journal, Feb., 1873. There are objections to the use of resonators and reflection which I cannot here explain.

Second method. If the plane of a free membrane be placed at

right angles to a wave-front it cannot vibrate, for both of its sides are simultaneously acted on by impulses of the same phase and of equal energy. Thus, by bringing the plane of a membrane into that azimuth where it remains at rest we shall have found the plane passing through the center of origin of the sound. I also propose the use of two resonators, or of two ear trumpets, placed at the ends of a long horizontal rod which rotates around a vertical axis. I may thus obtain an increase in the aural parallax. By rotating the horizontal rod around its center I may be able to bring the two sonorous sensations either to disappear, or to become of equal intensity, and by these indications to arrive at the direction of a sound. The last mentioned idea may develop into something useful to the mariner who has to ascertain the *direction* of a fog signal.

II. Botany and Zoology.

1. *Botanical Contributions*, separately issued from the current (eleventh) volume of the *Proceedings of the American Academy of Arts and Sciences.*—These are, first, a series of miscellaneous contributions, characters of new species, and several new genera, mainly Californian, by Asa Gray. The paper begins with the discrimination of two plants which have long been confounded, namely, *Sedum pusillum* of Michaux and *Diamorpha pusilla* of Nuttall. They grow together, but are distinct enough in appearance as well as in structure when seen in the living state, as they were by the author of this paper a year ago. There is a revision of the genus *Collinsia*, of the North American species of *Mimulus*, twenty-nine in number, and of *Monardella*, eleven in number.

The other papers are by Sereno Watson. 1. *On the Flora of Guadalupe Island*, Lower California, founded upon a unique collection of dried plants made by Dr. Edward Palmer. 2. List of the collection with Dr. Palmer's notes upon them. There is a notable amount of new species, and two new genera. These are characterized, as are the new *Gamopetalæ*, by Prof. Gray in his paper above mentioned, as to the remainder by Mr. Watson in his third article, entitled, *Descriptions of New Species of Plants chiefly Californian, with Revisions of certain Genera.* The other new species described and the revisions are mainly such as came to light in Mr. Watson's work on the *Polypetalæ* of the Botany of California, soon to be published. Among them are many plants of much interest, such, for instance as second species of the genera *Crossosoma*, *Lyrocarpa* and *Adolphia*. *Cercidium* is shown to belong to *Parkinsonia*. A revision is made of the North American species of *Trifolium*, also of *Lathyrus* and *Peucedanum*, both very critical works; and the cucurbitaceous genus *Megarhiza* of Torrey is re-established upon five species. Mr. Watson's descriptions, as usual, are in the English language,—an advantage in home but not for foreign use. A. G.

2. *Botanical Necrology* of 1875. On the home list only one name recurs to memory, that of

INCREASE ALLEN LAPHAM, LL.D. He died September 14, in the 64th year of his age. A beautiful tribute to his memory, read before the Old Settler's Club, of Milwaukie, by S. S. Sherman, Esq., has just been printed, and is noticed on a following page. An excellent portrait is prefixed.

The following botanists have deceased in Europe:

FRIEDRICH GOTTLIEB BARTLING, one of the oldest professors at Göttingen, a veteran teacher, but not a voluminous author; aged 77.

ALEXANDRE BOREAU, of Angers, France, author of the Flora du Centre de la France.

JOHN EDWARD GRAY, March 7, at the age of 75. Principally known as a zöologist, some of his earliest work was in botany. A notice of his life and services appeared in this Journal, vol. x, p. 78.

JEAN CHARLES MARIE GRENIER, one of the authors of the classical Flora de France, died at Besançon, in the 69th year of his age.

DANIEL HANBURY, died at Clapham, March 24, in his 50th year. A notice appeared in this Journal, vol. ix, p. 75. We learn that his scattered writings are to be collected.

RUDOLPH FREIDRICH HOHENACKER, died at Kirchheim in Wurtemburg, late in the preceding year, November 14, 1874. He was in early life a missionary at Astrakan, and was afterward in the Caucasian provinces. He was one of the founders of the Unio Itinerario, and he survived his associates, Steudel and Hochstetter.

LIEUT. GENERAL JACOBI, the monographer of *Agave*, died at Berlin, early in the year.

ERNST FERDIND NOLTE, of Kiel, a veteran botanist, who had retired from his professorship a year or two ago, died February 13, at the age of 84.

GUSTAVE THURET, died suddenly at Antibes, France, May 17, at the age of 58. A brief notice of this sad loss was given in vol. x, p. 67. Among other tributes to his memory is one by Rostafinski in the Botanische Zeitung, for July 30. Also one by Professor Farlow in Trimen's Journal of Botany, for January last.

ADOLPHE BRONGNIART. We learn that this veteran botanist and vegetable paleontologist died at Paris. A. G.

3. *Life Histories of Animals, including Man, or Outlines of Comparative Embryology*; by A. S. PACKARD, Jr. 8vo, 239 pp. with 268 cuts. New York, 1876. (Henry Holt & Co.)—This work consists of a series of papers published in the American Naturalist during the past year, with the addition of a few pages on mammals and nearly three on man. Although, according to the preface, the original papers have undergone "careful revision," we regret to notice many serious errors and inaccurate statements that have been allowed to remain, and are much less excusable in

the permanent book form than in mere magazine articles. Most of these errors must evidently be attributed rather to carelessness in the mode of statement than to lack of knowledge on the part of the author. Thus on page 187, after properly describing the zoëa of crustacea as having only "antennæ, jaws and foot-jaws" for locomotive appendages, he states that he has examined *Gelasimi* carrying eggs which "contained zoëæ, with the two claws alike, and it is probable that the strange inequality in size of the claws in these animals does not show itself until after one or more moults." What such an incongruous statement means can scarcely be imagined, for the "claws" and other legs are not even formed until a much later period, and it is well known that no such inequality exists in the adult females, nor even in the young males until after they become genuine little fiddler-crabs. On page 216 he says: "the tadpole is much less developed than the larval fish or any other vertebrate; the intestine is not yet formed," but in the next sentence he adds: "It is also a vegetarian, eating decaying leaves; the mouth is small and round, the alimentary canal is remarkably long, the intestine coiled up in a spiral, the mouth is small, destitute of a tongue." On page 157 he says of the Gephyrea: "In none of these worms are there bristles or indications of segments," forgetting the well-marked segments and conspicuous setæ of *Echiurus*, and the less numerous ones of *Thalassema* and other genera. On page 120 he says: "There is in the Annelids a dorsal and ventral blood-vessel, the circulatory apparatus being closed and more highly developed than in the Crustacea and Insects, *Limulus* excepted," but this is by no means true of all Annelids, for in many genera (*Polycirrus*, etc.,) there are no blood-vessels whatever, and many others have a very imperfect system of vessels. On page 117, fig. 126 is said to represent a later stage of *Loligo* than fig. 125, but the reverse is true. On page 78 it is said that "in the star-fishes and Holothurians, the alimentary canal opens into five voluminous cæcal appendages," and that these "are in connection with the complicated water tubes" (ambulacral tubes and suckers). The latter statement is entirely erroneous, or at least misleading, and the former is not true of most Holothurians, nor even of all star-fishes. The statement on page 79, that "in those star-fishes in which the alimentary canal is a blind sac, the eggs are emptied into the body cavity" is also incorrect, at least for most species. The statement (p. 70) that "in the Hydroids also the ovaries hang outside the body cavity" is inaccurate, as are also the statements (p. 63) that only *one case* of multiplication by fission has been observed among Hydroids, and on page 58, that the "ovaries" of *Hydra* "differ entirely in their mode of formation from the ovaries (gonophores) of the marine Hydroids, which are genuine buds." The account of *Physalia* (p. 65); that of the growth of septa in Polyps (p. 71); of the development of barnacles (p. 169), and many other paragraphs need revision. The peculiar mode of development of *Tubulariæ*, in which the embryo becomes an

"actinula" without going through a "planula" stage, is not alluded to, the planula stage being given as a stage of all Hydroids (p. 66). On page 336 "*Didelphia*" is used where *Monodelphia* is intended. The five diagrammatic figures on p. 225, given to illustrate birds (fowl), would serve better for mammalian embryology. The lists of works given at the end of each chapter are very incomplete and unsatisfactory, many of the latest and most important books being omitted from most of them. Thus under Hydroids the works of Hincks aud Allman, both of which contain much of importance on embryology, are omitted. The magnificent treatise on Tubularians by the latter is certainly one of the most important hitherto published, both for the embryology and structure of Hydroids. The recent extensive work on the Nemerteans by McIntosh is not mentioned, though it contains the embryology of the group. Cobbold's works are only once alluded to, and are not mentioned under those groups of Helminths upon which he has done the most. The very valuable works of G. O. Sars on various Crustacea, including the discovery of the very remarkable phenomena in the embryology of *Cladocera*, are not referred to. Most of these are works written in English, and should be well known to the author of a work on embryology. Certainly references to such works would have been more useful for most of his readers than those that he gives to special papers in the German and Russian periodicals, which are generally inaccessible, however valuable they may be. In spite of these defects the book will doubtless prove to be a very useful one, there being no other work in English covering the same ground. V.

4. *On some Remarkable Forms of Animal Life from the great deeps off the Norwegian Coast.* II. *Researches on the Structure and Affinity of the genus Brisinga, based on the study of a new species, Brisinga coronata;* by GEORGE OSSIAN SARS, (University-Programme for the last half-year, 1875. Christiania).—In this valuable memoir, which is illustrated by seven excellent plates, Professor Sars has given a detailed description of the anatomy, physiology, and development of the genus *Brisinga*, perhaps the most remarkable form of star-fish hitherto discovered. The author also discusses, at considerable length, its relations to other star-fishes, recent and fossil, as well as to Echinoderms in general, and the relation of Echinoderms to the Annelids. He regards *Brisinga* as the most generalized form of star-fish, and consequently of Echinoderms, and supposes it to be one of the little-modified survivors of a primitive type from which the other forms of Echinoderms have descended. It has affinities to the most ancient fossil starfishes of the Palæozoic rocks (*Protaster*, etc.)

The existence of a genuine vascular system, distinct from the general perivisceral cavity and its extensions, is denied both in the case of this genus and of other star-fishes. The author also states that there is no anal orifice, although there is, as in other star-fishes, a dorsal gland, with a narrow duct opening on the dorsal surface, and he suggests that this duct has in other star-fishes been

mistaken for an intestine, and its outlet for an anus, the existence of which, in any star-fish, he doubts. Prof. Sars adopts the view, previously advanced by Duvernoy, Huxley, and Hæckel, that an Echinoderm is a cluster (or "comus") composed of several articulated zoöids ("persons") united by their anterior ends. V.

5. *A Course of Practical Instruction in Elementary Biology;* by T. H. HUXLEY, assisted by H. N. MARTIN. 268 pp. small 8vo, without illustrations. (Macmillan & Co.) 1875.—The publishers have seen fit to over-burden this otherwise excellent little manual with an exorbitant price ($2.50 in the U. S.), which will doubtless prevent its adoption in many cases where it should be used. It contains very full descriptions of the structure of a number of diverse forms of plants and animals, with plain and explicit directions how to dissect and study them. V.

6. *Crustacea of Mexico and Central America.* Mission Scientifique au Mexique et dans l'Amérique Centrale, publié par ordre du Ministre de l'Instruction Publique. *Etudes sur les Xiphosures et les Crustacés de la région Mexicane*, par M. ALPHONSE MILNE-EDWARDS. 4to, Paris: 1re et 2e livraisons, pp. 56, plates 1–14, 1873; 3e livr., pp. 57–120, plates 15–20, 1875.—These memoirs are published in the same elaborate and sumptuous style as the other works of this series, and are by far the most extensive and important contribution yet made to our knowledge of the crustaceans of the tropical region of America. The first forty pages and twelve plates are devoted to an elaborate study of the anatomy of Limulus, the substance of which had previously appeared in the Annales des Sciences Naturelles during the delay in the publication of the present work. The second memoir is devoted to a systematic account of the stalk-eyed Crustacea of the Mexican region, including Central America, Lower California, the Galapagos, and the West Indies. This memoir, beginning with the Maioidea, treats, thus far, of the *Pericerinæ*, *Pisinæ*, and *Mithracinæ*, including twenty-three genera, or sub-genera, and seventy-four species. A large proportion of the species are represented on the plates by beautiful figures of the entire animals, and numerous details. Twelve of the species and five of the genera are described as new. The author states, in the introduction, that a large part of the collections obtained by the Mexican Commission were destroyed, during the bombardment of Paris, by the explosion of a Prussian shell which had passed through the cases containing the conchological collections. On this account the work is based to a considerable extent on collections received from the United States, particularly from the Smithsonian Institution and the Museum of Comparative Zoology at Cambridge. S. I. S.

7. *Cumacea from great depths in the Arctic Ocean;* by G. O. SARS. 12 pp. 4to, with 4 plates. (From the Svenska Vetenskaps-Akademiens Handlingar, Bandet xi; Stockholm, 1873.)—This is the third of Professor Sars's richly illustrated memoirs on the Cumacea, and treats of five species from the Arctic Ocean. *Diastylis polaris* and *D. stygia* are from the remarkable depths of 950 and 2600 fathoms respectively. S. I. S.

8. *Moa or Dinornis of New Zealand.*—Remains of skeletons of fifteen Moas have been discovered along the beach, north of Whangarei Heads, sixty miles north of Auckland. Several human skulls and a complete human skeleton in sitting posture (the usual burying posture among the natives) were found with the Moa bones. Previously, no Moa bones had been found north of Auckland.—*Nature*, Feb. 3.

9. *Carnivorous Reptiles having some features of Carnivorous Mammals from the Triassic(?) of South Africa.*—Professor OWEN has described, in a paper read before the Geological Society of London on February 2d, a carnivorous reptile, named by him *Cynodracon major*, which has the compressed sabre-shaped canines of the Lion of the genus *Machærodus*, and resembles Carnivores both in the canines and incisors. In the lower jaw the bases of eight incisors and of two canines (very inferior in size to the canines of the upper jaw) are visible, and the canines are separated by a diastema from the incisors. In this character, as in the number of incisors, the fossil resembles a *Didelphys*. "The left humerus is 10½ inches long, but is abraded at both extremities; it presents characters, in the ridges for muscular attachment, in the provision for the rotation of the forearm, and in the presence of a strong bony bridge for the protection of the main artery and nerve of the forearm, which resemble those occurring in carnivorous mammals, and especially in the Felidæ, although these peculiarities are associated with others having no mammalian resemblances." "Prof. Owen discusses these characters in detail, and indicates that there is, in the probably Triassic lacustrine deposits of South Africa, a whole group of genera (including *Galesaurus*, *Cynochampsa*, *Lycosaurus*, *Tigrisuchus*, *Cynosuchus*, *Nythosaurus*, *Scaloposaurus*, *Procolophon*, *Gorgonops and Cynodracon*), many represented by more than one species, and all carnivorous, which have more or less decided mammalian analogies; and to them he gives the general name of *Theriodonts*.

The common characters of the Theriodonts are as follows: dentition of the carnivorous type; incisors defined by position, and divided from the molars by a large laniariform canine on each side of both jaws, the lower canine crossing in front of the upper; no ecto-pterygoids; humerus with an entepicondylar foramen; digital formula of the fore foot 2, 3, 3, 3, 3 phalanges.—*Proc. Geol. Soc. of Feb.* 2, *in Ann. Mag. Nat. Hist.*, for March, 1876.

10. *The Crustacean, Artemia salina, changed in some of its characters by changing the saltness of the water in which it lives.*—W. J. SCHMANKEWITSCH announces, that by increasing the saltness of the water in which the *Artemia salina* lives, a modification goes on from generation to generation, until the caudal lobes finally disappear, and the form is that in the *Artemia Mühlhausenii;* and by reversing the process, the caudal lobes grow out again and become those of *A. salina.* In 1871 the salt marshes about Odessa contained great numbers of *A. salina*; the waters then marked only 8° Baumé. Afterward, on the repair of a dyke,

the saltness increased to 14° Baumé in the summer of 1872, and 25°, in August, 1874. The changes in the species were then first noted. The author afterward corroborated the fact by experiments on Artemiæ reared in captivity in water of which the saltness was gradually increased. A change also takes place, correspondingly, in the form of the branchiæ, and in the number of apodal segments. —*Ann. Mag. N. H.*, March, 1876, from *Zeitschr. wiss. Zool.*, xxv, Suppl. i, 1875, p. 103, pl. 6.

III. Astronomy.

1. *Astronomical and Meteorological Observations made during the year* 1873, *at the U. S. N. Observatory, with Appendix;* Rear-Admiral B. F. Sands, Superintendent. Gov. Printing Office.

This volume contains the record of a year's work at the Observatory, and is evidently the record of first rate work. The Appendix by Professor Newcomb has been already noticed in our February Number.

If the use for several years of one value of the latitude of the Observatory for reducing observations, made by the mural circle, and of another value for observations made by the transit circle, were the deliberate choice of the Superintendent, astronomers would probably think his decision unwise. The same also must be said of using a different latitude each year for the final tables of north polar distances, derived from the observations of the transit circle. It would also look better, to say the least, if the results were given in the same denomination, instead of north-polar distance for one instrument, and declination for the other.

These things look not so much like the deliberate choice of the Superintendent, as the kind of little irregularities that must be expected from a system that makes little account of scientific fitness in appointing the Superintendent of a scientific institution. We hope for better things from the present Superintendent. H. A. N.

2. *Auxiliary Tables for determining the angle of position of the sun's axis and the latitude and longitude of the Earth referred to the Sun's equator:* by Warren De La Rue; 20 pp. 4to, London, 1875. Printed for private circulation.

IV. Miscellaneous Scientific Intelligence.

1. *Third Report of the Settle Caves (Victoria Cave) Committee of Exploration;* by R. H. Tiddeman. (Rep. Brit. Assoc. 1875.) —Mr. Tiddeman was Secretary of the Committee in charge of the exploration, the other members being Sir John Lubbock, Prof. Hughes, Prof. Dawkins, and Mr. L. C. Miall. The Victoria Cave afforded the preceding year, among remains of *Ursus spelæus*, *U. ferox*, *Hyæna*, *Rhinoceros hemitæchus*, *Bison*, *Cervus elephas*, and molars of *Elephas antiquus*, a bone pronounced by Prof. Busk to be a human fibula. Thick bowlder deposits covered the entrance to the cavern, and hence the remains were pronounced to

be pre-Glacial. This *third* Report states that great progress had finally been made in uncovering the glacial deposits at the entrance, in which were bowlders of all sizes up to several tons in weight. The question whether "these glacial deposits, which rest upon the older bone-beds containing the remains of extinct mammals and man, are in the position which they occupied at the close of the Glacial conditions, or have subsequently fallen into their present site," is answered by stating that the new facts "go to prove the first alternative." In one chamber (numbered D) the upper bone-bed afforded remains of the *Badger*, *Horse*, *Pig*, *Reindeer*, *Goat* or *Sheep*, and was peculiar in the abundance of *Reindeer* remains and the absence of the Elephant, Rhinoceros, Hippopotamus, Hyæna, as if it were of the Reindeer epoch, or later; the lower afforded bones of *Hyæna*, *Brown Bear* (?), *Elephas antiquus*, *Rhinoceros hemitœchus*, *Hippopotamus*, *Bos primigenius;* while, in both, there occur remains of *Man*, *Fox*, *Grisly Bear* and *Red Deer*. A piece of a human rib was found during the year in the lower bed, near where the fibula was taken out.

2. *Air and its Relations to Life;* by Walter Noel Hartley, F.C.S., Kings College, London. 263 pp. 12mo. New York, 1875. (D. Appleton & Co.)—This very readable little volume contains the substance of a course of six summer lectures delivered in 1874 at the Royal Institute of Great Britain. The author exhibits the rare faculty of presenting the results of exact science in a form perfectly intelligible and attractive to intelligent people not familiar with the technical language of science. The researches of the most trustworthy investigators are cited with good judgment from the days of Black and Lavoisier to those of Retenkofer, Angus Smith and Pasteur. Indeed it is not easy to say where else in English we can find so full a statement of the researches of Pasteur as in chapter four of Mr. Hartley's essay.

3. *Geological and Geographical Survey of the Territories*, Prof. F. V. Hayden *in charge.*—Bulletin No. 1, Vol. II, of this Survey has appeared It contains seven articles. Three, by, severally, Messrs. Holmes, Jackson and Bessels, treat of the Ancient Ruins of Southwestern Colorado, Utah and Arizona, and are illustrated with twenty-nine octavo plates, of cliff dwellings and other ruins, pottery, utensils, crania, etc. Of the remaining four, three are short articles on the Ute Indians, by E. A. Barber; and a fourth consists of descriptions of thirty-one new species of fossil Coleoptera from the Tertiary formations of the West, by S. H. Scudder. The volume is full of interesting facts in American Archæology, and the maps and plates illustrate well the subjects discussed.

3. *Compressed Peat.*—Peat pressed into blocks and made so compact that a cubic foot weighs 85 to 100 pounds, is manufactured by Mr. A. E. Barthel, of Detroit, Michigan, and sells for one and a half dollars per ton.

4. *Report of the Superintendent of the U. S. Coast Survey*, showing the progress of the Survey during 1872. This report contains 18 appendixes, among which we note the report of Assis-

tant Cutts and Prof. Young of Astronomical and Meteorological observations made at Sherman, Wyoming Ter., pp. 75–172; and a preliminary report on transatlantic longitude, by Prof. Hilgard, pp. 227–234.

Notices of the following new publications have been excluded from this number by want of space.

Geological Survey of Ohio. Paleontology, vol. ii. 436 pp. 8vo, with numerous plates. A volume of great value.

Mineral Resources West of the Rocky Mountains. 7th Annual Report, by R. W. Raymond. 540 pp. 8vo. Washington, 1875.

Second Geological Survey of Pennsylvania. Report of Progress in the Clearfield and Jefferson District of the Bituminous Coal-fields of Western Pennsylvania, by Franklin Platt. 296 pp. 8vo, with 139 wood-cuts and 10 maps and sections. Harrisburg, Pa., 1874.

Bulletin of the U. S. National Museum. No. 1 by E. D. Cope, and No. 2 by J. H. Kidder. Smithsonian Institution, 1875.

Report on the Geology of a portion of Colorado, by John J. Stevenson. 372 pp. 4to, 1876. Reprinted from Lieut. Wheeler's Survey Report, vol. iii.

Report of the Chief Signal Officer, War Department, 1875. 476 pp. 8vo, with numerous maps.

OBITUARY.

I. A. Lapham, LL.D.: a Biographical Sketch, by S. S. Sherman. 80 pp. 8vo, 1876.—This memoir is a very just tribute to the memory of Dr. Lapham, who died at Milwaukee, Wisconsin, in September, as already stated in this Journal. Dr. Lapham was a man of very varied knowledge and scientific labors. Early in life, while engaged in engineering duties, he began a collection of plants, which at his death numbered 8,000 species, and he also published papers on the geology of portions of Ohio. Moving to Milwaukee in 1836, he commenced observations on the topography, soil, mineral and other industrial resources, of Wisconsin, and on the commerce and navigation of the lakes, and kept tables of the daily temperature, rain-fall, and other meteorological phenomena; and in 1844 he published for Wisconsin a volume of 250 pages, on these topics. He afterward contributed Agricultural, Botanical and Geological papers to the Transactions of the Wisconsin State Agricultural Society, among them a valuable treatise of nearly 100 pages on "The Grains of Wisconsin and adjacent States," a paper which he afterward extended to a manuscript volume of 574 pages on the Gramineæ of the United States, but which remains unpublished. The fluctuations in the level of Lake Michigan early engaged his attention, and in 1849 he announced his discovery of "a slight lunar tide in Lake Michigan." The study of Indian mounds of Wisconsin occupied much of his time, and as early as 1836 he called attention to a turtle-shaped mound at Waukesha. He was the first to notice that many of these aboriginal earthworks are "gigantic basso-relievos of men, beasts, birds and reptiles." His well known and highly valued "Antiquities of Wisconsin," printed by the Smithsonian Institution, is a large quarto volume, containing 55 plates and numerous wood-engravings, all from his own

drawings. One of his last labors was the preparation of a series of models of the Indian mounds for the Centennial Exhibition of 1876.

Another subject which occupied him was Meteorites; and peculiar crystalline markings in a Wisconsin meteorite, first noticed by him, were designated by Dr. J. Lawrenee Smith, in a paper on the meteorite in this Journal (II, xlvii, 271), *Laphamite markings.*

The establishment of the Signal Service Bureau at Washington in 1869 was due largely to personal effort and influence on the part of Mr. Lapham.

Dr. Lapham was placed, in 1873, at the head of the Geological Survey of the State of Wisconsin, a position for which he was well fitted: and the Survey went forward with energy and important results through that year and 1874. To the misfortune of science and the State, he was deposed at the close of 1874, and, through political management, a man ignorant of geology was substituted. It was a serious disappointment to Dr. Lapham, and not less so to all friends of science in the land. "His abrupt dismissal was all the more cruel because this was the only opportunity he ever had of perfecting and giving to the public in a permanent form the results of a life-work in the geology, natural history and industrial resources of the State."

Dr. Lapham was active also in all educational movements; a founder of the Milwaukee Female College, a liberal contributor to the Cabinet of the Wisconsin State University, and one of the founders of the Wisconsin Historical Society, and of the Wisconsin Academy of Sciences.

Rev. Augustus Wing, of Rochester, Vermont, died in Whiting, in that State, on the 19th of January, aged sixty-seven years. Mr. Wing was a graduate of Amherst College, of the class of 1835. Although not a geologist by profession, a large part of his time for many years had been spent in the study of the rocks of Vermont, and especially of the crystalline limestone, quartzyte and slates of the central portion of the State. By the discovery of Lower Silurian fossils in the crystalline limestone at several different localities he threw much light on the geology of metamorphic New England. In August of the past year the writer had the pleasure of accompanying Mr. Wing on a visit to some of his localities that were of special interest for their fossils or for their illustration of the stratification of the rocks, and this was his last scientific excursion, excepting one of a few days during the following fortnight. His almost child-like delight over the places of his remarkable discoveries as he pointed them out; his earnestness in making known his conclusions and in supporting them against all expressed doubts; his eager, rapid gait as we walked over the rocks and hills, made him an especially agreeable companion, and suggested no thought of the end that was so soon to come. Before parting, he promised to send for this Journal an account of his discoveries, as in fact he had done before. But he disliked writing, and it was not sent. We hope that his notes may yet afford material for such a paper.

J. D. D.

APPENDIX.

ART. XLI.—*Principal Characters of the* BRONTOTHERIDÆ; by O. C. MARSH. With four plates.

THE remains of a well-marked group of gigantic mammals are abundant in the lowest deposits of the Miocene, on the eastern slope of the Rocky Mountains. These animals, which have been named by the writer, *Brontotheridæ*, equaled the Eocene *Dinocerata* in size, and resembled them in some important features. They do not, however, belong to the same order, but constitute a distinct family of Perissodactyles. Four genera of this family are now known, as shown below, but *Brontotherium* is the only one represented by sufficient remains to clearly indicate its structure and affinities; and hence this genus will be first described, and mainly used to illustrate the group.

Brontotherium Marsh, 1873.*

The skull in *Brontotherium* is long and depressed, and resembles that of *Rhinoceros.* The occipital region is extended vertically, and deeply concave posteriorly. The vertex is concave longitudinally, and convex transversely. The general form of the skull is shown in the cut given below, figure 1.

1.

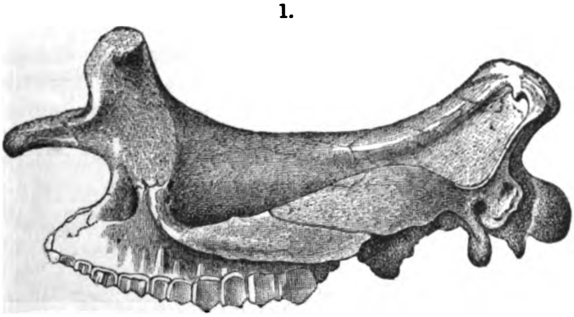


Figure 1. Skull of *Brontotherium ingens* Marsh. Side view; one-twelfth natural size.

There is a pair of large horn-cores on the anterior part of the skull, in front of the orbits. They stand on the maxillaries,

* This Journal, vol. v, p. 486. Also vol. vii, p. 81, Jan., 1874, and vol. iv, p. 245, March, 1875.

like the middle pair in *Dinoceras*, the nasals forming only the inner margin of the base. These protuberances are placed transversely, as in modern Artiodactyles, and extend upward and outward. They vary much with age, and probably differed with the sex. There are large air cavities in the base of these horn-cores. The nasal bones are greatly developed, and firmly co-ossified. Their anterior extremities are produced, and overhang the large narial orifice. The premaxillaries are diminutive, and do not usually extend forward so far as the end of the nasals. The infra-orbital foramen is very large. The lachrymal forms the anterior border of the orbit. The latter is small, and continuous with the elongated temporal fossa. There is no postorbital process on the frontal. The zygomatic arches are massive, and much expanded. The malar extends forward beyond the lower margin of the orbit. The zygomatic process of the squamosal is elevated, and more or less incurved above. There is a large postglenoid process, which forms the anterior border of the external auditory meatus. The latter is bounded behind and below by the post-tympanic process of the squamosal. There is a large par-occipital process. The occipital condyles are large, and well separated. Their position indicates that the head was declined when in its natural position. There is a large condylar foramen, and a distinct alisphenoid canal. The palate is deeply excavated, especially in front. The posterior nares extend forward between the last upper molars.

The brain cavity in *Brontotherium* is small, and its form is shown in Plate XI, the figures of which are drawn from a nat-

2.

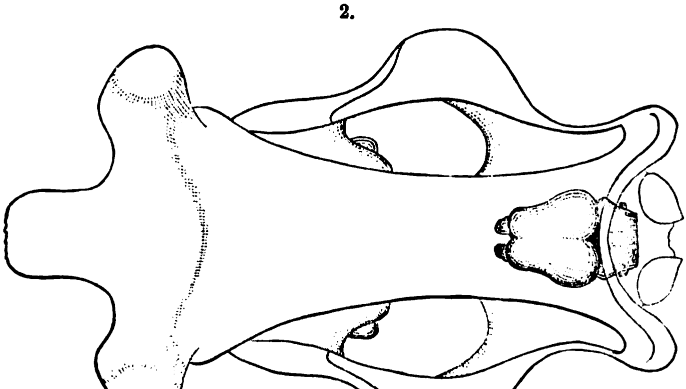


Figure 2. Outline of skull and brain cavity of *Brontotherium ingens*. Top view; one-tenth natural size.

ural cast of the brain-case of *B. ingens* Marsh. The size of the entire brain compared with that of the cranium is shown in the accompanying cut, figure 2.

The cerebral hemispheres did not extend at all over the cerebellum, and little if any over the olfactory lobes. The latter were of moderate size, and separated by a wide osseous septum. The hemispheres were comparatively large, and much convoluted. The Sylvian fissure is well-marked in the cast, and some of the other principal divisions are indicated. The cerebellum was small. There was a rudimentary tentorial ridge. The pituitary fossa is distinctly marked. The foramina for the optic nerves are quite small.

The mandible in *Brontotherium* has a wide condyle, and a slender coronoid process. The angle is rounded, and slightly produced downward. The symphysis is depressed, elongated, very shallow in front, and completely ossified. (Plate XII.)

The dental formula of *Brontotherium* is as follows:—

$$\text{Incisors,}\frac{2}{2};\ \text{canines,}\frac{1}{1};\ \text{premolars,}\frac{4}{3};\ \text{molars,}\frac{3}{3}\times 2=38.$$

The upper incisors are quite small. (Plate X.) The canine is short and stout, and placed close to the first premolar. The upper premolars have all essentially the same structure, viz: two external connate cusps, with their outer faces nearly plane, and two inner cones closely united. The anterior cone is connected with the opposite outer cusp by a transverse ridge, which has behind it an elongated depression, more or less divided by projections from the outer posterior cusp. In the upper true molars, the external cusps have their outer surfaces deeply concave, while the inner cones are low and separate. The lower incisors were small, and evidently of little use. The two next the symphysis were separated from each other. The lower incisors are not unfrequently wanting, and in old animals the alveoli may, perhaps, disappear. Careful examination, however, will usually show indications of them. The lower canine is of moderate size, and separated from the premolars by a short diastema. The lower molars are of the *Palæotherium* type, and agree essentially with those of *Menodus.*

The neck in *Brontotherium* was stout, and of moderate length. The cervical and most of the dorsal vertebræ are distinctly opisthocœlous. The atlas is large, and much expanded transversely. The axis is massive, and has its anterior articular faces much broader than in the *Dinocerata.* The odontoid process was stout and conical. The posterior articular face is concave, and oblique. The transverse processes apparently had no foramen for the vertebral artery. The epiphyses of the vertebræ are loosely united in most specimens, as in the Proboscidians. The lumbars are slender, and smaller than the dorsals. There are four vertebræ in the sacrum. The caudal vertebræ indicate a long and slender tail.

The limbs of the *Brontotheridæ* were intermediate in proportion between those of the Elephant and the Rhinoceros. The scapula is large, with a prominent spine and small coracoid process. The humerus is stout, and its great tuberosity extends above the head. The radial crest is prominent, and the entire distal end is occupied by the articulation. The olecranon cavity is shallow, and the condylar ridge similar to that of the Elephant, but not continued so far up the shaft. The radius and ulna are separate. The ulna has its olecranon portion much compressed. Its distal end is much smaller than in *Rhinoceros*, and has no articular face for the lunar. The radius is stout, and its distal end expanded. The carpal bones form interlocking series. They are shorter than in *Rhinoceros*, and support four well developed toes of nearly equal size. (Plate XIII, figure 2.) The metacarpal bones are shorter than those of *Rhinoceros*, the first phalanges longer, and the second series shorter. All the toes had "navicular" sesamoid bones, similar to that on the coronary bone of the horse. The ungual phalanges are short and tubercular, as in the *Dinocerata* and *Proboscidea.*

The pelvis is much expanded transversely. The femur has a small third trochanter, and its head a deep pit for the round ligament. At the distal end, the anterior articular surface is narrow, and the two edges are of nearly equal prominence, as in the Tapir. The patella is elongate, and has a strong vertical keel on its articular face. The tibia is stout, and has a distinct spine. The fibula is separate and entire, but quite slender. The calcaneum is much elongated. The astragalus is shorter than in the Rhinoceros, and the superior groove more oblique. The cuboid face is larger than in *Rhinoceros.* The navicular has its distal facets subequal. There were three toes of nearly equal size in the pes, the first and fifth being entirely wanting. (Plate XII, figure 1.) None of the bones of the skeleton are hollow.

There appear to be four well marked genera in the *Brontotheridae*, now known, which may be distinguished as follows:

1. *Menodus* Pomel.* (*Titanotherium* Leidy, 1852.)

$$\text{Dentition} = \text{Incisors}\frac{2}{2};\ \text{canines}\frac{1}{1};\ \text{premolars}\ \frac{4}{4?};\ \text{molars}\frac{3}{3}.$$

Diastema behind upper canines. Basal ridge on inner side of upper premolars not continuous. Nasals short. A postorbital process. Third trochanter rudimentary or wanting. Type *M. Proutii.*

2. *Megacerops* Leidy. (*Megaceratops* Cope), (*Symborodon* Cope in part.)

$$\text{Dentition} = \text{Incisors}\frac{2}{0};\ \text{canines}\frac{1}{1};\ \text{premolars}\frac{4}{3};\ \text{molars}\frac{3}{3}.$$

* Bib. Univ. de Genève, x, p. 75, Jan., 1849.

Diastema behind upper canines. Inner basal ridge on upper premolars not continuous. Nasals more elongated. A postorbital process. Third trochanter rudimentary or wanting. Type *Megacerops Coloradensis* Leidy.

3. *Brontotherium* Marsh, (*Symborodon* Cope, in part.) (*Miobasileus* Cope.)

$$\text{Dentition} = \text{Incisors}\frac{2}{2}; \ \text{canines}\frac{1}{1}; \ \text{premolars}\frac{4}{3}; \ \text{molars}\frac{3}{3}.$$

No superior diastema. Strong continuous basal ridge on inner side of upper premolars. No postorbital process. Third trochanter distinct. Type *B. gigas* Marsh.

4. *Diconodon* Marsh (*Anisacodon*).

$$\text{Dentition} = \text{Incisors}\frac{0}{1}; \ \text{canines}\frac{1}{1}; \ \text{premolars}\frac{4}{3}; \ \text{molars}\frac{3}{3}.$$

No superior diastema. Strong inner basal ridge on upper premolars. Last upper molar with two inner cones. No postorital process. Type *D. montanus* Marsh.

In the dentition and skeleton, the *Brontotheridæ* more nearly resemble the Eocene *Diplacodon*, than any other American genus, and they may yet prove to be nearly related. The animals of that genus were of much smaller size, and entirely without horns. The relations of the *Brontotheridæ* to the genus *Chalicotherium* Kaup, cannot at present be determined.

In comparing the *Brontotheridæ* with the equally gigantic *Dinocerata* of the Eocene, several striking points of resemblance will be at once noticed; especially the presence of horn-cores in transverse pairs: the general structure of the limbs; and the short and thick toes. The differences, however, between these two groups are still more marked. In the *Brontotheridæ* there is but a single pair of horn-cores, and no crest around the vertex. The structure and number of the teeth are quite different, while the small canines and huge molars contrast strongly with the elongated canine tusks and diminutive molars of the *Dinocerata*. The latter, moreover, have two very large dependent processes on each ramus of the mandible; the cervical vertebræ flat; the femur without a third trochanter; and at least an additional toe in each foot.

Among the features which this group shares with the *Proboscidea* may be mentioned: the superior extension of the condylar ridge of the humerus; the short thick toes; and the late union of the epiphyses with the centra of the vertebræ. The last character appears to belong especially to mammals of very large size, and probably indicates late maturity, and great longevity.

The *Brontotheridæ* nearly equaled the Elephant in size, but the limbs were shorter. The nose was probably flexible, as in the Tapir, but there was evidently no true proboscis.

All the known remains of the *Brontotheridæ* are from east of the Rocky Mountains, in the Miocene beds of Dakota, Nebraska, Wyoming, and Colorado.

Yale College, New Haven, March 16, 1876.

EXPLANATION OF PLATES.

Plate X—*Brontotherium ingens* Marsh. Superior premolar and molar teeth; bottom view. One-third natural size.

Plate XI—*Brontotherium ingens.* Cast of brain cavity. Figure 1, top view; figure 2, side view. One-half natural size.

Plate XII—*Brontotherium gigas* Marsh. Lower jaw. Figure 1, top view; figure 2, front view; figure 3, side view. One-sixth natural size.

Plate XIII—*Brontotherium.* Figure 1, hind foot; figure 2, fore foot. One-sixth natural size.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XLII.—*On supposed changes in the Nebula* M. 17 = h. 2008 = G. C. 4403. (R. A. 18^h 12^m $33^s.1$; N. P. D. 106° 13′ 36″; 1860·0); by EDWARD S. HOLDEN.*

I. *Historical Notes—Observations*:—This nebula was discovered by Messier and is number 17 of his list (*Connaissance des Tems* 1784). It has been carefully studied since 1800, by Sir John Herschel (1833–37), Lamont (1837), Mason (1839), Lassell (1862), Huggins (1865), Trouvelot (1875), and Trouvelot and myself (1875). These observations, so far as they are published, are to be found in the following works:—

HERSCHEL: Observations of Nebulæ, etc., made at Slough; *Phil. Trans.*, 1833, p. 498 and Plate XII, fig. 35.
HERSCHEL: *Results of Astronomical Observations at the Cape of Good Hope*, p. 8 and Plate II, fig. 1.
LAMONT: *Ueber die Nebelflecken*, 1837, fig. X.
LAMONT: *Annalen der K. Sternwarte bei München*, band xvii, p. 332 and fig. 21, Plate VIII.
MASON: *Transactions American Phil. Soc.*, vol. vii, 1840, p. 165, Plate VI.
LASSELL: *Mem. R. A. S.*, vol. xxxvi; Plates VII, VIII, figs. 33, 33A.
HUGGINS: *Philosophical Transactions* 1866, p. 385.

The later observations are unpublished.

I extract from these various authorities such portions as will be of use for subsequent reference.

From Herschel's paper (*Phil. Trans.*, 1833):—

"The figure of this nebula is nearly that of a Greek capital omega, Ω, somewhat distorted, and very unequally bright. Messier perceived only the bright [eastern] branch of the nebula now in question, without any of the attached convolutions which were first noticed by my father. The chief peculiarities which I

* This article has in part appeared in the Popular Science Monthly; and this Journal is indebted to Messrs. Appleton & Co. for all but one of its excellent illustrations.

have observed it it are—1. The resolvable knot in the [eastern] portion of the bright branch, which is in a considerable degree, insulated from the surrounding nebula; strongly suggesting the idea of an absorption of the nebulous matter; and, 2. The much feebler and smaller knot at the [northwestern] end of the same branch, where the nebula makes a sudden bend at an acute angle. With a view to a more exact representation of this curious nebula, I have at different times, taken micrometrical measures of the relative places of the stars in and near it, by which, when laid down as in a chart, its limits may be traced and identified, as I hope soon to have better opportunity to do than its low situation in this latitude will permit."

S.

W.  E.

N.

Fig. 1.* HERSCHEL 1833.

From *Ast. Obs. at the Cape of Good Hope*:—After explaining that his first figure is far from accurate Herschel says:—

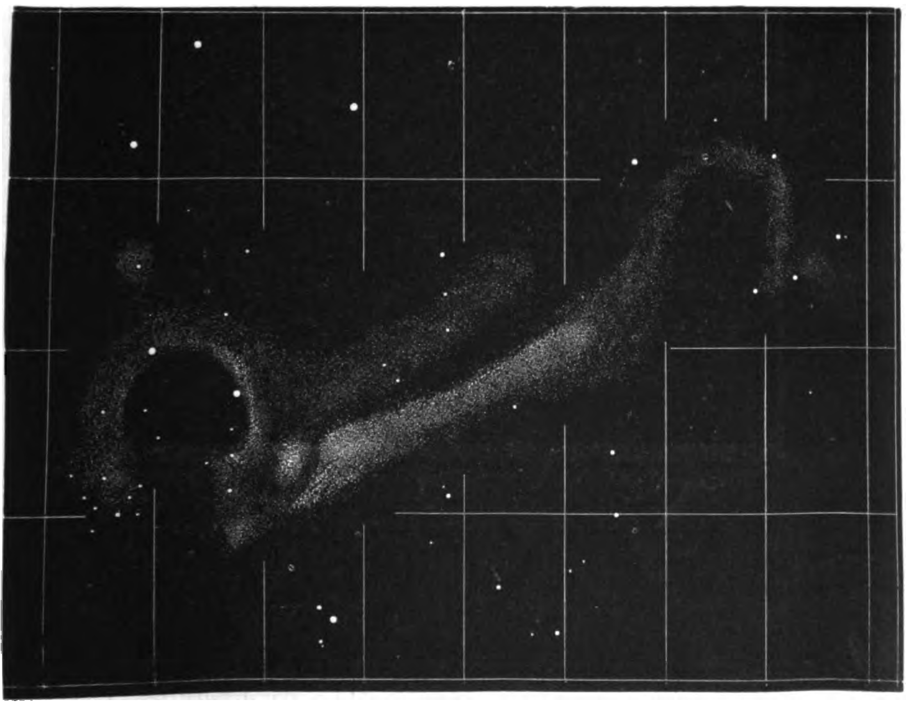
"In particular the large horseshoe-shaped arc . . . is there represented as too much elongated in a vertical direction and as bearing altogether too large a proportion to [the eastern] streak and to the total magnitude of the object. The nebulous diffusion, too, at the [western] end of that arc, forming the [western] angle and base-line of the capital Greek omega (Ω), to which the general figure of the nebula has been likened, is now so little conspicuous as to induce a suspicion that some real change may have taken place in the relative brightness of this portion compared with the rest of the nebula; seeing that a figure of it made on June 25, 1837, expresses no such diffusion, but represents the arc as breaking off before it even attains fully to the group of small stars at

* For the use of the cuts which are given with this article, I am indebted to the courtesy of Dr. Youmans, Editor of the Popular Science Monthly.

the [western] angle of the Omega. . . . Under these circumstances the arguments for a real change in the nebula might seem to have considerable weight. Nevertheless, they are weakened or destroyed by a contrary testimony entitled to much reliance. Mr. Mason, a young and ardent astronomer, ... whose premature death is the more to be regretted, as he was, so far as I am aware, the only other recent observer who has given himself with the assiduity which the subject requires to the exact delineation of nebulæ, and whose figures I find at all satisfactory, expressly states that *both* the nebulous knots were well seen by himself and his coadjutor Mr. Smith on August 1, 1839, i. e., two years subsequent to the date of my last drawing. Neither Mr. Mason, however, nor any other observer, appears to have had the least suspicion of the existence of the fainter horseshoe arc attached to the [eastern] extremity of Messier's streak. Dr. Lamont has given a figure of this nebula, accompanied by a description. In this figure [our Fig. 3], the nebulous diffusion at the [western] angle and along the [western] base line of the Omega is represented as very conspicuous; indeed, much more so than I can persuade myself it was his intention it should appear."

S.

W.



E.

N.

Fig. 2. Herschel 1837.

Herschel's Star-positions obtained in 1837 are given in Table II.

From Lamont's observations, *band* xvii, *Annalen der K. Sternwarte bei München*, p. 332 *et seq.*, I extract the following:—with regard to Sir John Herschel's drawing in the Cape of Good Hope Observations he says " . . . . bei mehreren Sternen scheint . . . . die Abweichung so gross, dass erst durch künftige Beobachtung entschieden werden muss, ob Aenderungen vorkommen, oder ob die Unterschiede in den Messungen ihren Grund haben."

S.

W.

E.

N.

Fig. 3. Lamont 1837.

Lamont's measures are mostly of position angle, and all of these which are directly comparable with Lassell's measures I have placed in Table III. We find two important notes on the physical aspects of the nebula as follows:—"Im Nebel kommt ein Knoten vor, den Sir J. Herschel als auflösbar betrachtet, während ich von Auflösbarkeit keine Andeutung bemerken konnte. Die Länge des Nebels-Knotens schätzte ich = Distanz (2) — (28) [Lassell's nomenclature] und die Breite = ½ Distanz (2)—(7). An 2 August [1837] fiel mir eine Stelle zwischen (2) und (40) auf, wo ich einen

verschwindend kleinen Stern oder ein Häuflein solcher Sterne wahrzunehmen glaubte."

In regard to the credence due to Lamont's sketch the following sentence is important (*op. cit.* p. 305): "Was die . . . beigefügten Zeichnungen betrifft, so sind sie nur als Skizzen zu betrachten, welche blos den Zweck haben, die Messungsresultate verständlich zu machen."

S.

W.  E.

N.

Fig. 4. MASON and SMITH 1839.

From Mason's paper above cited:—

"*Things certain:*—1. The 'resolvable knot' mentioned by Herschel is isolated or nearly so, from the rest of the nebula.

2. The smaller knot is apparently not affected with this peculiarity.

3. Of the faint bend or loop [horseshoe] the *following* half is brighter than the *preceding*.

4. The bright branch fades away gradually to the [east]; it is convex [towards the south.]

5. The external angle of the nebula stretches down from the star [8] (of Lassell's nomenclature; see our sketch map, figure

8) towards the *n. p.* much farther than in Herschel's drawing." (our fig. 1.)

"*Nearly certain*:—1. The bright branch is more definitely bounded on its southern side than upon the northern. [??]

2. The 'resolvable knot' of Herschel has either a second nucleus or involves a faint star in its [south] margin."

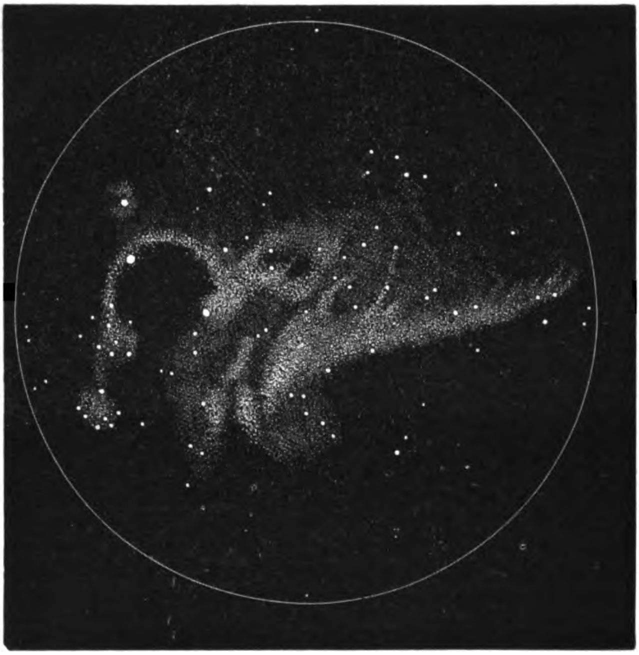
"*Strongly suspected*:—5. Just [south] of star [2] is a portion a little brighter than the rest of the bend."

Mason's star positions are given in Table I.

Lassell gives no description of the nebula, and we extract only his measures of the co-ordinates of eleven of the brightest stars, which are contained in Table IV, and which we shall use as standard positions to which all others are to be referred.

S.

W.



E.

N.

Fig. 5. LASSELL 1862.

We give Lassell's figure above, remarking that it was constructed, as indeed all the preceding ones have been, by first measuring the relative position of the brighter stars, then inserting by careful eye-estimates the fainter ones, and finally by drawing among these stars, guided by their configurations, the details of the nebula itself.

In Huggins' paper already cited (p. 385) we find the following:—

"Lord Oxmantown informs me that in the observations of this nebula at Birr Castle, there is no mention of resolvability; and that 'the central part to the right [east?] of star *α* [No. 2?] consists of bunches or patches of bright nebulosity with fainter nebulosity intervening.' The spectrum of this nebula indicates that it possesses a gaseous constitution.

One bright line only was seen, occupying in the spectrum apparently the same position as the brightest of the lines of nitrogen. When the slit was made as narrow as the intensity of the light would permit, this bright line was not so well defined as the corresponding line in some of the other nebulæ under similar conditions of the slit, but remained nebulous at the edges.

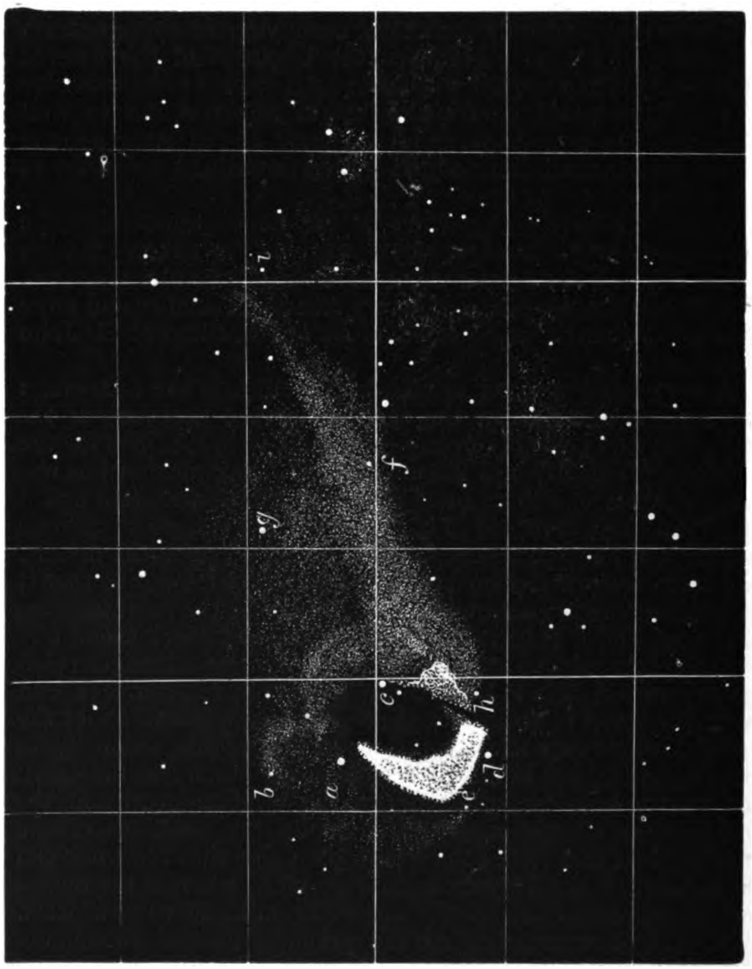
When the brightest portion of the nebula containing the nucleus or 'bright knot' was brought upon the slit, in addition to the bright line a faint narrow continuous spectrum was seen. The bright knot appeared in my telescope smaller and more condensed than it is represented in the drawings of Sir John Herschel."

A very rapid method of drawing nebulæ, is the following: it yields to the first in the accuracy of the positions of the stars, but it is probably even superior to it in facilities for the correct representation of the nebula and stars considered as one mass. A piece of glass ruled carefully into squares (see figs. 6 and 7) and this is placed in the focus of the eyepiece so as to be plainly visible; the telescope is then directed upon the nebula, and a clock-work motion is applied to the telescope so that it follows the nebula accurately. Some one of the brighter stars is chosen, and it is kept by means of the clock-work accurately in the corner of one of the squares. A piece of paper ruled into squares similar to those of the glass reticle is provided, and on it the observer dots down the various stars in and about the nebula. This may take two, three or four nights, according to circumstances, but in all cases it requires much less time than the micrometric measurements of the brighter stars and the troublesome allineations required to fix the positions of the smaller stars and it has the great advantage that the work can be done in a perfectly dark field of view, whereas the micrometric measures demand the use of illuminated wires at least. After the stars are inserted, the principal lines of the nebula are put in, not only by the star groups, but also by the squares themselves. For my own use I have had constructed two reticles: one ruled in squares like those seen in figs. 6 and 7, and another in which the heavy-lined large squares (each containing nine small squares, see fig. 6) are still present, but are subdi-

vided into small squares by lines parallel to their own diagonals. After making all the use possible of the first reticle, the second is put in, and an entirely new set of reference-lines is obtained, making an angle of 45° with the old set. This, of course, could be equally obtained by revolving the first reticle through an angle of 45°, but it is not quite so convenient.

E.

S.



N.

Fig. 6. Trouvelot 1875.

W.

After the stars and the principal lines of the nebula are inserted a new and higher power eye-piece is used, and the drawing is concluded by means of this. Fig. 6 is an example

of a drawing of the Horseshoe Nebula made in this way by M. Trouvelot, of Cambridge. Massachusetts, with his 6⅓ inch refractor.*

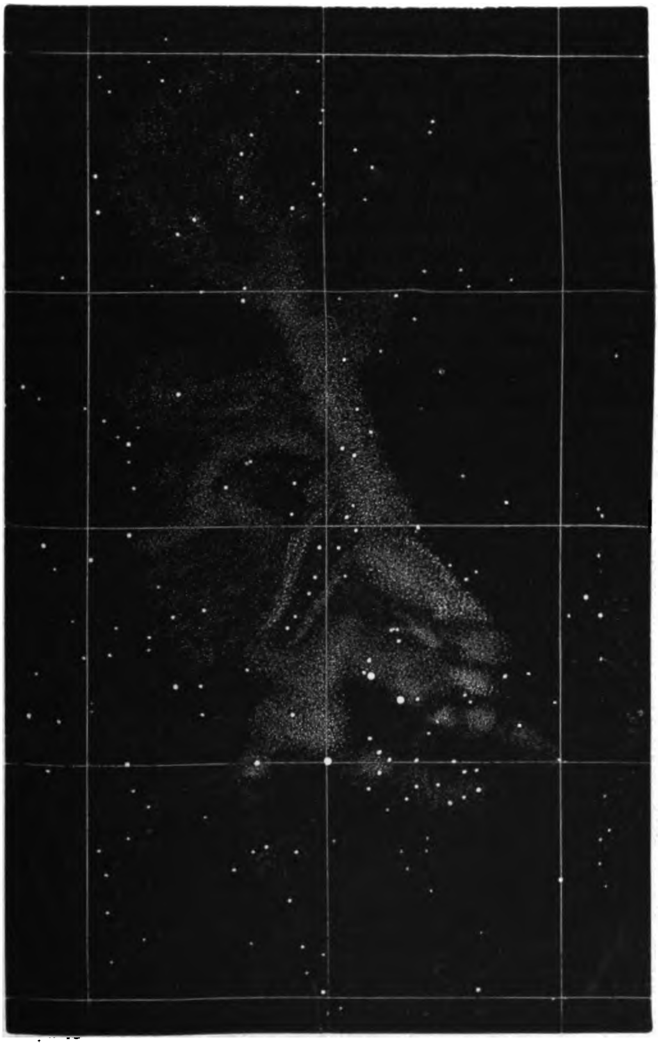


Fig. 7. Trouvelot and Holden 1875.

During the last summer M. Trouvelot was invited by the Superintendent of the United States Naval Observatory to visit

* That portion of the nebulosity within the horseshoe has been made far too bright by the engraver in this figure, but the shape is properly kept.

Washington for the purpose of making drawings of nebulæ, etc., by means of the twenty-six-inch Clark refractor. By the courtesy of Admiral Davis I am able to give a drawing of the Horseshoe Nebula as delineated by M. Trouvelot from observations made jointly by him and myself.

Pretty much the same method was adopted in this drawing as in fig. 6, but the vastly more complex structure of the nebula itself is what might have been expected from an increase of eighteen times in the light, over M. Trouvelot's six-inch telescope.

It may be said of the drawing from which fig. 7 was copied, that nothing is there laid down about which the slightest doubt is entertained; and although, in some respects, it was made in greater haste than is desirable, yet it is sufficiently accurate to found an argument on, for or against variation in the shape of any of the *brighter portions* of the nebula. The fainter portions of fig. 7 are too well defined and too bold, but it is, in general, a good representation.

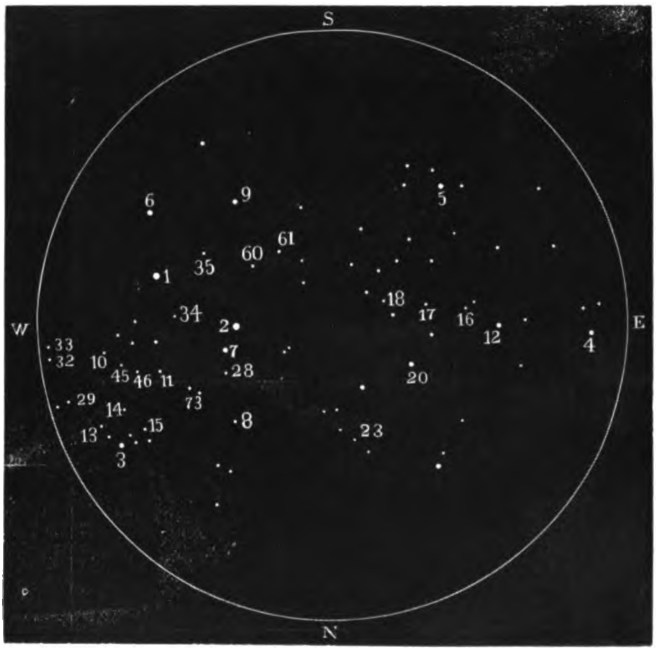


Fig. 8. Sketch-map of Stars (Lassell).

For the purpose of studying this and other nebulæ, I have had the original drawings photographed *on a uniform scale and in such a way as to cause all the photographic prints to represent*

the nebulæ as they would appear in a refractor. It is only in this way that several drawings, made both by reflectors and refractors can be satisfactorily and minutely compared. The cuts of the present paper were reproduced from such photographic prints, and they are on a scale of one inch = 266″·2; in the present paper, however, all *conclusions* are drawn from an examination of the original engravings, although references are made to the cuts for convenience.

My own notes on the physical aspect of this nebula are as follows:—

"The brighter portions of this nebula give evidence of resolvability. In particular all the brighter parts of the "horseshoe," and of the long branch extending from star 8 to star 71, seem under intense looking, to be just ready to break into small stars. Many small points of light were put down both by myself and by M. Trouvelot, but it was soon found that such a task was endless and of far less importance than the correct delineation of the nebulosity. For nearly all the details of the drawing M. Trouvelot is responsible, as time did not allow of that careful and independent comparison which it is desirable should always be made; but it may be said briefly, that there are no conjectures laid down in the original. Everything is as it was seen. I confined my attention principally to the space limited by stars, 1, 6, 9, 61, 63, 70, 20, 8, 3, 10, on account of the evidence from older drawings that this portion has moved relatively to the stars; and I can vouch for its general accuracy.

This portion is sufficiently accurate to found an argument for or against variability upon. For example. I am sure that the brightest mass of nebulosity *follows* star No. 1, as M. Trouvelot has drawn it, and I am sure that the general direction of the dark channels between stars 7 and 53 is correct in the drawing."—[Sept. 21 to Oct. 2, 1875.]

Trouvelot's star co-ordinates were obtained graphically from the original sketch and are given in Table IV.

II. *Comparison of Star-positions.*

The only relative star-places completely determined which are of the highest accuracy are those of Lassell. "Eleven of the principal stars were measured and the remainder laid down by careful estimation, while some approximation to their proportionate magnitudes is preserved in the drawing. The numbers are generally, but not uniformly, in the descending order of magnitude." The star-positions of Lamont are of high accuracy, but unfortunately only angles of position were measured in most cases. Mason's work was done while he was an undergraduate at Yale College, with a telescope of his own construction mounted as an alt-azimuth, and in the intervals of his collegiate

duties, and although every endeavor was made to obtain high accuracy, and above all to determine the limits of error, yet his instrumental means were comparatively inadequate. He estimates the average error of his star-positions in this nebula to be about 1ˢ·6 in R. A. and 25″ in δ (*see* pp. 192 and 193 of his memoir already quoted).

Most of Herschel's stars were inserted by allineations. The method chosen by M. Trouvelot and myself has already been noticed. It may be of interest to remark that the mean error of Trouvelot referred to Lassell is about 7″·7 in R. A. and 5″·3 in N. P. D. The larger residual in R. A. is due to imperfect running of the driving clock of the Equatorial. When this clock is in its usual good condition I believe that this error will not exceed 6″, a quantity which is not appreciable in any drawing of a considerable nebula which can be put upon a quarto page.

TABLE I.—MASON'S STAR-POSITIONS.

Lassell's number.	Mason's number.	Mason's magnitude.	Mason's R. A. 1830·0.	Mason's δ 1830·0.	Remarks.
33 ?	1	14·15	18h 10m 28·9s	−16° 13′ 47″	When the identification of one of Mason's stars with one of Lassell's is at all doubtful a question-mark (?) is added in the first column.
32 ?	2	14.15	29·3	13 11	
13	4	13	32·9	12 24	
10	5	14	33·3	13 51	
3	6	12·13	34·74	11 45	
14	7	15	35 3	12 43	
15	8	15	36·5	11 50	
6	9	12	38·51	17 15	
11	10	15	38·5	13 23	Other stars can be identified but only so many are included as will suffice to determine the limits of the nebulosity. The same remarks apply to the following tables.
1	11	11	38·56	15 44·4	
73 ??	12	14·15	42·2	13 5	
35	13	14	43·3	16 15	
7	14	12·13	45·32	13 58·9	
28	15	16	46·0	13 30	
2	16	11	46·84	14 36·0	
8	17	14·15	10 47·3	12 24	
18 ?	22	16	11 1·0	15 21	
23 ?	24	14	6·1	10 57	
5	25	12	6·19	18 17	
17 ?	26	16	7·7	14 58	
20	27	14	8·3	12 15	
16 ?	28	16	11·1	14 31	
12	29	12	18 11 20·3	−16 14 4	

TABLE II.—HERSCHEL'S STAR-POSITIONS.

Lassell's number.	Herschel's number.	Herschel's magnitude.	ΔR.A. from 11 in arc.	ΔN.P.D. from 11 in arc.	Class.	Remarks.
13	2	12	−91″·5	−201″·6	3	In the column "Class" the numbers have the following signification: — 1. denotes that the differences of R. A. and N.P.D. were *measured:* 2. denotes that these differences were derived from alineations from known stars; 3. denotes that these differences were derived from the position of the star as laid down by the eye on the chart. Columns 4 and 5 have been deduced from the corresponding data given by Herschel, Obs. C. G. H. p. 9.
10	4	14	−61·5	− 82·6	2	
3	6	11	−54·0	−232·8	1	
15	9	15	−15·0	−198·0	3	
6	10	11	−13·5	+115·2	1, 2	
1	11	9	0·	0·	1	
11	13	13	+ 4·5	−122·4	2	
73 ??	15	13	+73·5	−158·4	2	
35	16	12	+96·0	+ 49·2	2	
8	17	13	+109·5	−201·6	2	
7	18	11	+109·5	−112·8	2	
28	19	15	+112·5	−151·2	2	
2	20	10	+123·0	− 66·0	1	
9	21	12	+129·0	+134·4	2	
5	31	11	+423·0	+134·4	2	
12	35	13	+528·0	− 86·4	2	

TABLE III.—COMPARISON OF LASSELL'S AND LAMONT'S STAR-POSITIONS.

Lassell's number.	Lamont's number.	1862. Lassell's pos. angle, from 2.	1837. Lamont's pos. angle, from 2.	Δp. Lassell − Lamont.	Remarks.
1	3	239·1°	238·3°	+0·8°	No. 1. Lassell's distance 133·1″; Lamont's 134·3″; Δs = −1·2″.
3	15	314·5	314·0	+0·5	
5	28	124·7	125·0	−0·3	
7	2	342·4	341·3	+1·1	* Correcting Lamont's measure of Aug. 2 from 173° 0′ to 177° 0′: omitting it altogether, Lamont's angle becomes 357·8.
8	17	357·6	*357·4	+0·2	
10	10	279·8	279·4	+0·4	
11	8	299·1	299·6	−0·5	

TABLE IV.—STAR-POSITIONS OF LASSELL, MASON, HERSCHEL AND TROUVELOT.

The co-ordinates are measured from star 2 (Lassell).

No.	Herschel 1837.		Mason 1839.		Lassell 1862.		Trouvelot 1875.		Remarks.
	Δα.	Δδ.	Δα.	Δδ.	Δα.	Δδ.	Δα.	Δδ.	
1	−123·0″	+ 66·0″	−124·2″	+ 68·4″	−114·2″	+ 68·3″	−116·1″	+ 64·5″	N+, S−; E+, W−.
3	−177·0	−166·8	−181·5	−171·0	−162·9	−160·3	−163·4	−157·0	
4	....	....	....	....	+492·6	− 18·6	+473·0?	*− 8·6?	
5	+300·0	+200·4	+280·2	+221·0	+284·3	+196·8	+281·7	+187·0	
6	−136·5	+181·2	−125·0	+159·0	−120·7	+158·2	−124·7	+165·6	
7	− 13·5	− 46·8	− 22·8	− 37·1	− 12·3	− 38·8	− 30·1	− 43·0	* Some doubt as to identity.
8	− 13·5	−135·6	− 6·9	−132·0	− 5·9	−137·8	− 17·2	−137·6	
9	+ 6·0	+200·4	....	....	+ 4·6	+177·5	+ 10·8	+178·4	
10	−184·5	− 15·6	−203·1	− 45·0	−189·8	− 32·7	−187·0	− 21·5	
11	−118·5	− 56·4	−125·1	− 73·0	−113·3	− 63·0	−118·2	− 64·5	
12	+405·0	− 20·4	+351·9	− 32·0	+365·9	− 12·8	+352·6	− 6·4	

TABLE V.—COMPARISON OF LASSELL, MASON, HERSCHEL AND TROUVELOT.

No.	Lassell—Herschel,		Lassell—Mason,		Lassell—Trouvelot.		Remarks.
	$\Delta\alpha$.	$\Delta\delta$.	$\Delta\alpha$.	$\Delta\delta$.	$\Delta\alpha$.	$\Delta\delta$.	
1	8″·8†	2″·3†	10″·0	0″·1	1″·9	3″·8	* Some doubt as to identity. Those of Herschel's stars whose position was micrometrically determined are marked †, the rest are estimated. It will be noted that Mason's residuals are quite within his limits of error.
3	14·1†	6·5†	18·6	10·7	0·5	3·3	
4	....	....	....	....	19·6*	10·0*	
5	15·7	3·6	4·1	24·2	2·6	9·8	
6	15·8†	23·0	4·3	0·8	4·0	7·4	
7	1·2	8·0†	10·5	1·7	17·8	4·2	
8	7·6	2·2	1·0	5·8	11·3	0·2	
9	1·4	22·9	....	....	6·2	0·9	
10	5·3	17·1	13·3	12·3	2·8	11·2	
11	5·2	6·6	11·8	10·0	4·9	1·5	
12	39·1	7·6	14·0	19·2	13·3	6·4	

It may be seen from table III that the relative positions of the principal stars of this group are the same during the period of observation. Precession will cause changes of relative position far less than the errors of observation.

III. *Comparison of Star-magnitudes.*

It will be remembered that Lassell's numbers represent generally the order of brightness of the stars. Mason's magnitudes were reduced by himself so as to correspond to those of Herschel, and this was done in his own thorough way, by comparing his estimates of the brightness of stars in *Nebula Cygni*, with those previously given by Herschel. Lamont and Trouvelot give no magnitudes.

Table VI contains most of the information available on this subject.

TABLE VI.—COMPARISON OF STAR-MAGNITUDES.

Lassell's number,	1	2	3	5	6	7	8	10	11	12	13	15	28	35	73 ??
Herschel's magnitude,	9	10	11	11	11	11	13	14	13	13	12	15	15	12	13
Mason's magnitude,	11	11	12·13	12	12	12·13	14·15	14	15	12	13	15	16	14	14·15

From this we see that the order of magnitude is as follows:

Lassell,	1,	2,	3,	5,	6,	7,	8,	10,	11,	12,	13,	15,	28,	35,	73;
Herschel,	1,	2,	3,	5,	6,	7,	13,	35,	8,	11,	12,	73,	10,	15,	28;
Mason,	1,	2,	5,	6,	12,	3,	7,	13,	10,	35,	8,	73,	11,	15,	28.

A *suspicion* of variability exists as to stars 12, 13, 10, 35, 8, 73, 11, 15,* 28, but 35, 8, 15 and 73 are the only cases in which a *probability* of variability exists and even in these cases it is slight. If my identification of Lassell's 73 on the other drawings is correct, there is a mistake in his magnitude. A tolerably bright star is very near its place.

* See p. 359.

IV. *Examination of the Question as to the Motion of the Nebula relative to the Stars.*

It will be remembered that the seven drawings of this nebula which we possess were made in the years 1833, 1837, 1839, 1862 and 1875 quite independently, by different observers and different telescopes. It is evident that in cases where these different drawings *agree*, there can be no doubt as to the existence of the feature delineated. The non-existence of any prominent feature not given is probable, although not certain. To examine the question proposed at the head of this section, it will be advantageous to divide the drawings into three groups, the *first* consisting of all figures made before 1840 (Herschel's, Lamont's, Mason's), the *second*, of Lassell's fine delineation, which is entitled to very great weight, and the *third*, of the two drawings made by M. Trouvelot, one at Cambridge and the other at Washington. It is well to recall the fact that Herschel's two figures were made with his 20-foot reflector of 18½ inches aperture; Lamont's with the Munich refractor of 11 inches; Mason's with a 14-foot reflector of 12 inches; Lassell's with his 4-foot reflector; M. Trouvelot's first drawing with a 6½ inch Merz refractor, and the Naval Observatory drawing with the very perfect Clark refractor of 26 inches.

To prove the existence of a change it is necessary and sufficient to show that a prominent feature which the first group of drawings gives, is in a different position relative to the stars in Lassell's drawing and that the motion thus shown is confirmed and continued by the two figures of 1875, much greater weight being given to the work of the larger instrument in 1875. It must be remembered that with two instruments of *equal light*, hardly more discrepancy in the positions of the *brighter* portions of the nebula is to be expected than in the star-positions, for these positions are determined by the stars themselves and can be assigned with almost no error, in a nebula which contains so many stars as the one under consideration. The fainter portions may vary greatly from the smaller to the larger instruments. No relative numerical weight can be assigned to the various drawings, even if it were desirable to do this, but it may be remarked that Mason's, Herschel's (1837), Lassell's and that of the Naval Observatory are of the greatest authority. Herschel's first drawing, he himself does not consider comparable in accuracy to his second: Lamont's is of great weight as to the relative star-positions, but was not intended as anything more than a "sketch," and Trouvelot's first figure while undoubtedly of high accuracy as far as his instrumental means were satisfactory, is yet not strictly comparable with the work of Herschel's and Lassell's reflectors, or to his own work with the Naval Observatory refractor.

In Table VII, I have thrown into a convenient form the evidence for or against a motion of the "horseshoe" with reference to its contained stars. It will be remembered that so far as our evidence goes (see Tables III and V) the relative position of the stars themselves has not changed; as the agreement of the careful measures of Lamont and Lassell (whose observations are separated by 25 years) is quite as good as can be expected. In Table V none of the residuals are greater than the limits of error supposed by the various observers to exist in their own work; and most of them are less. It is moreover, plain that if the star-positions had changed while the nebula also moved, even this fact would not effect the question as to whether the line joining two stars, say 10 and 11, was *inside* or *outside* of the nebulosity. It is therefore in this way that I have presented the evidence concerning the motion of the "horseshoe" relative to the principal stars. That is, I take a certain line, as that one joining stars No. 10 and 11 and terminated by them, and arranging the drawings chronologically, I enquire how this line is situated with regard to the nebula in the various delineations Is it all inside, or partly outside? If partly outside, what fraction of its length is outside? The single exception to this method is that of star 11, whose remarkable situation in the various drawings of the nebula first led me to suspect a change.

The number of *independent* proofs of the change, is not quite so great as the number of columns in Table VII, since most of the evidence rests upon the positions of stars 1, 34, 35, 2, 10, 11.

It will be seen that not only is the change progressive from group I to group II and from this to group III but that in general it is even progressive from drawings 1 to 7.

The exception to this general progression is fig. 6, made by M. Trouvelot with his 6½ telescope shortly before the drawing No. 7. It will be observed that in many particulars his description corresponds to that given by the figures 1 to 4; which might indicate that the differences observed are only such as might be expected from the employment of different telescopes by different observers. This explanation I do not believe to be the correct one, for the reason that, *first*, no explanation is thus attained of the large and consistent differences between the drawing of Lassell and that of the Naval Observatory; and *second*, that an examination of the position of the line of maximum brightness in the early figures, and in that made by M. Trouvelot at Cambridge, shows that so far as the evidence goes, *the line of maximum brightness* in the western half of the horseshoe, is now further to the east than it was in 1834–9. It is evident that if the line of maximum brightness was plainly laid

TABLE VII.

Group.	Authority.	Star, or Line joining two Stars, under examination.							
		No. 11.	10–11.	10–14.	10–13.	10–3.	1–34.	2–35.	2–7.
I.	1. Herschel 1833.	not inside on foll'g edge.	all inside.	all inside.	all inside.	all inside.	34 not laid down.	middle outside ends inside.	inside.
I.	2. Herschel 1837.	outside.	E. $\frac{4}{6}$ outside.	all inside.	all inside.	all inside.	all outside.	inside.	inside.
I.	3. Lamont 1837.	outside.	E. $\frac{12}{16}$ outside.	all inside.	inside.	inside.	N. $\frac{2}{3}$ outside.	all inside.	all inside.
I.	4. Mason 1839.	outside.	E. $\frac{14}{16}$ outside.	all inside.	all inside.	all inside.	34 not laid down.	all inside.	all inside.
II.	5. Lassell 1863.	inside on following edge.	all inside.	N. $\frac{1}{3}$ outside, star 14 quite outside.	nearly all outside.	N. $\frac{1}{3}$ inside.	all outside.	at least $\frac{1}{2}$ outside.	all inside.
III.	6. Trouvelot 1875.	not inside near following edge.	nearly all inside.	inside.	all inside.	all inside.	N. $\frac{1}{3}$ outside.	middle outside ends inside.	outside?
III.	7. Trouvelot and Holden 1875.	inside on following edge.	W. $\frac{1}{2}$ outside?	S. $\frac{1}{3}$ outside, star 14 quite inside.	nearly all outside.	N. $\frac{1}{3}$ outside.	all inside.	all inside.	inside on preceding edge.

Abbreviations used in above Table. N. = north; S. = south; E. = east; W. = west.
For a *star*: (see column 1) inside *or* outside = quite inside *or* quite outside of the nebulosity.
For a *line joining two stars*: inside *or* outside is not so expressive of *certainty* as *all* inside *or* outside.

down by each observer no difficulty would be found in making an exact comparison, and it will be found from an examination of the original engravings that the tracing of such a line on them is a matter of some difficulty. Still, it is believed that sufficient definiteness can be attained to show that on the whole Trouvelot's Cambridge drawing is consistent with the conclusion above given. In particular, his star No. 1 is not at all on the *following* edge of the nebulosity, but well within it, towards the *preceding* side, thus totally differing from the appearances laid down by all earlier drawings. Again, he represents the space *within* the horseshoe and *north-following* star No. 1, to be largely filled with nebulosity, quite consistently with the Naval Observatory drawing, and utterly different from the drawing of Lassell (see Fig. 6). This fact is of great importance, since, if the nebulosity *followed* star No. 1, in 1862, Lassell would have so represented it (as he did not) and as Trouvelot has so drawn it, it is plain that an important change must have occurred to render it possible for a six-inch aperture to show nebulosity in 1875, in a space perfectly void of nebulosity to Lassell's great reflector in 1862. *On the whole, then, these drawings show that the western end of this nebula has moved relatively to its contained stars from* 1833 *to* 1862, *and again from* 1862 *to* 1875, *and always in the same direction.*

I conceive that this is the best conclusion that can be drawn from the *ensemble* of the drawings. If we confine our attention to the three best ones, viz: Herschel's (1837), Lassell's (1862), and that of the Naval Observatory (1875), this conclusion comes out with greater distinctness. There is only one important feature in these three drawings which does not strictly agree with this supposition, namely that star No. 1 is in the same position with reference to the nebulosity in the first two of these which were made at an interval of twenty-five years and that they both differ from the last drawing made thirteen years after Lassell's. In every other respect the agreement is strictly with the above conclusion, and however much weight I might have been inclined to give to this disagreement, if the only data were those of the drawings, I cannot regard it as final in the light of a most careful examination of the nebula on the very fine night of March 21, 1876, when the various drawings were compared with the heavens. I add from the observing books a literal copy of my recorded observations on that occasion.

Extract from Observing-Book.

"1876. March 21. 16^h–17^h. Observer HOLDEN, Recorder, D. P. TODD.

Omega-Nebula. R. A. 18^h 12^m N. P. D. 106°·2. Magnifying power 175.

Star No. 1 brighter, but not much than 2. It *precedes* $\frac{9}{10}$ of the nebulosity of the *preceding* hook of the horseshoe. The line joining 1 and 10 is barely inside the nebulosity. The line joining 10 and 3 is inside the nebulosity but not much. 11 is just on *following* edge of the nebulosity. 34 *follows* the *west* branch of horseshoe, about $\frac{1}{2}$ the distance 2–7 [this is a rough estimate only] and is clear of any nebulosity. The middle $\frac{1}{3}$ of the line 6–1 is in the dark. The line 6–35 is all in the nebula. 8, 73, 11 about the same magnitude; 73 is in faint nebulosity, on the *preceding* edge of it. Between 11 and 73 very faint nebulosity which joins these two stars. Line 3–13 is just inside the nebula.—Star No. 1 certainly *precedes* $\frac{9}{10}$ths of west branch of horseshoe. Line 1–34 has its *west* $\frac{7}{10}$ths in nebula. 34 seems to be in the dark. Certainly a connection across 11–73 more distinct than in Naval Observatory drawing—more definite.

Line 10–11 is all inside nebulosity.

" 1–36 " " "

" 10–13 runs through fainter nebulosity.

13, 14, 10 are on *following* side of a bay which is filled with very faint nebulosity. 43 brighter than 15. 44>42>15 but the inequality is not great. 15 is the faintest star of 43, 44, 42 and 15.

The dark space within the horseshoe and bounded by 2, 7, 73, 11 is elliptic; the largest diameter is perpendicular to the line 8–14, and the diameters are as 6 to 4. It seems more regular in shape than in Naval Observatory sketch. Line 1–36 crosses fainter part of nebula about $\frac{1}{3}$ of the way from 1 to 26 and nearer 1. *Preceding* the line 1–10 is a darker space about equal in width to the distance 1–6. *Preceding* that, the sky is nebulous for 10′ at least. [This requires confirmation.] There is a faint prolongation from 6 towards *south preceding*. The shape of Herschel's resolvable knot is correctly laid down by Trouvelot. Two stars at its southern point and a star at or near junction of the two prongs of this knot. Sky more transparent than I have ever seen it. Much annoyed by the forming of clouds."

It will be seen that it cannot be doubted that star No. 1 is *now* in a position relative to the nebulosity quite different from that laid down by Lassell in 1862. Further, all the earlier drawings except Herschel 1837, put star No. 1 well within the nebula, and hence we are forced to the conclusion that the west half of the horseshoe has moved with reference to *this* star. Trouvelot's drawing with his small telescope is the only one not showing a similar and consistent motion with reference to the group of stars 10, 11, 3, 13, 15, etc., and even here we find evidence of changes in the same direction from the earlier drawings and the conclusion of the motion of the west one-half of the horse-

shoe with reference to its contained stars acquires new weight. The eastern half of the horseshoe, or at least that portion of it north of stars 2 and 7 shows on the contrary no evidence of such motion.

The observed changes in the *drawings* may be best accounted for by supposing a bodily shifting of the whole of the horseshoe in a plane nearly perpendicular to the line of sight, and on a pivot situated somewhere in the region of star No. 8, though, of course, it is not supposed that this is a real explanation of the physical changes.

A careful study of the evidence relating to the *Messierian* streak indicates no motion with reference to the contained stars. Graphic methods lead to the angles of position of this portion given below, with which I have incorporated the results of measures by D'Arrest and Schoenfeld.

Herschel, 1833:	p=119°.	†Schoenfeld, 1862:	p=112°,
Herschel, 1837:	p=119°.	mean of two, 115°, 110°.	
Lamont, 1837:	p=113°?	Lassell, 1863: ?	
Mason, 1839:	p=115°.	Trouvelot, 1875:	p=113°.
*D'Arrest, 1855:	p=122°,	Naval Observatory, 1875:	p=119°.
mean of two, 128°, 116°.			

To sum up:—Tables III and V show that the stars have remained in their relative positions from 1837 to 1875; and a consideration of the drawings, whether taken as a whole or considered according to their relative importance, shows that the horseshoe has moved with reference to the stars while the *Messierian* streak has not moved, and that therefore *we have evidences of a change going on in this nebula.*

This may be a veritable change in the structure of the nebula itself such as was suspected by Schrœter, confirmed by Otto v. Struve and again confirmed by myself in the Nebula of Orion, or it may be the bodily shifting of the whole nebula in space in some plane inclined to the line of sight.

A remarkable instance of a proper motion of this latter kind is that of the *Trifid Nebula* G. C. 4355, which has moved since 1833 so that the remarkable triple-star which was then quite clear from the nebulosity in a dark space formed by the junction of the three dark channels, is now by the evidence of Lassell (1863) Winlock and Trouvelot (1874) and myself (1875) well involved, the motion being confirmed by Herschel's drawing at the Cape of Good Hope (1837) and Mason's of about the same date.

The importance of the theoretical conclusions as to the constitution and distance of the nebulæ, to be derived from the first well-authenticated instance of the variation in form of any one nebula, have seemed to me to justify the discussion of the

* Abhand. d. K. Sach. Ac. d. Wissenschaften, Bd. v.
† Ast. Beob. Mannheim. Zweite Abth., 1875.

imperfect evidence now existing in regard to the one under consideration; and it must be remembered that no matter how inadequate this evidence may at first sight appear to be, it is yet as full, minute and complete as that relating to any single nebula except that of Orion; and if the drawings here considered are not sufficient to prove a change or the absence of a change, we are reluctantly driven to the conclusion that the work done by astronomers in this direction has been largely wasted. I hope that the evidence here adduced may be deemed of sufficient importance to warrant the great expense of time and labor necessary to a detailed monographic study of this nebula, which may serve for future reference. There is probably no nebula visible in the northern hemisphere more worthy of such examination.

U. S. Naval Observatory, April, 1876.

ART. XLIII.—*Brief Contributions from the Physical Laboratory of Harvard College.* No. XVIII.—*On the effect of thin plates of Iron used as armatures for Electro Magnets, and a new form of Induction Coil;* by JOHN TROWBRIDGE, assistant Professor of Physics.

IN a paper presented to the American Academy of Arts and Sciences, April 13, 1875, I showed that the application of armatures to two straight electro-magnets, which formed the primary circuit of a Ruhmkorff coil more than doubled the strength of the induction current produced by breaking the primary circuit. When, however, the circuit of the secondary coil was not closed, and a spark was allowed to jump across the interval between its poles, the striking distance of the spark and its power to charge a condenser did not seem to be notably increased by the application of armatures to the electro-magnets of the primary circuit. My experiments at that time were made with solid iron cores; and I now resume these experiments with bundles of fine iron wires in place of the solid iron cores. The mechanical difficulty of making the ends of the bundle of fine iron wires constituting the cores plain surfaces was overcome by dipping them in melted solder and then filing the ends smooth. In this way I had no trouble in applying the armatures so that they should lie upon a plain surface. The resistance of each of the two induction coils covering the two straight electro-magnets was 6000 ohms; and that of each of the straight electro-magnets, ·34 of an ohm. The diameter of the bundles of fine iron wires constituting the cores was 5 cm. and the length of the electro-magnets 28 cm. Condensers of

various sizes were placed in the primary circuit. The results given in this paper were obtained by the use of a condenser of about one farad. The method of experimenting was to charge a condenser of one-third of a farad; and then to discharge this condenser through a galvanometer. If we express the quantity of electricity received by the condenser by Q, the electromotive force by E, and the capacity of the condenser by C, we have $Q=\frac{2nt}{\pi}\sin\frac{1}{2}\theta$, where n is the reduction factor of the galvanometer, t the time of vibration of the magnet, and θ the angle through which it swings under the effect of the change. Knowing the reduction factor of my galvanometer, I had thus the means of reducing my results to absolute measure. But I speedily found that the relative results obtained by the proportions

$$Q:Q'=\sin\tfrac{1}{2}\theta;\ \sin\tfrac{1}{2}\theta'=E:E'$$

would present the points of this investigation in as clear a manner as if the results had been reduced to absolute magnetic measure. My first experiments were made with solid armatures.

TABLE I.

Without armatures. Tan θ.	With armatures. Tan θ'.
80	90
70	80
90	100
60	70
70	85
80	90
Mean, 75	86

TABLE II.

Without plates.	With plates.
80	400
70	380
90	370
60	400
70	370
80	400
Mean, 75	Mean, 386·6

In table I the numbers are the deflections of the reflecting galvanometer expressed in millimeters, and the distance of the scale from the magnet was one meter. In this case the gain by the use of the armatures was trifling, being only about fourteen per cent. These results were obtained by charging the condenser of one-third of a farad, by sparks one millimeter in length. On a closed secondary circuit, however, a gain of one hundred per cent was clearly seen in the strength of the induced currents produced by breaking the primary circuit. The question, how to make this increase in the strength of the induced current by the employment of armatures apparent on a broken secondary circuit, became an interesting one. It seemed at first as if the application of armatures, by maintaining the temporary magnetization of the iron cores would be detrimental rather than otherwise. I next tried the effect of bundles of thin iron plates, which were placed, as armatures, upon

both poles of the electro-magnet, thus making a magnet of a horse-shoe form. On charging the condenser, I found a very great increase in quantity, which was manifested by the swing of the galvanometer needle; the indicator being entirely off the scale.

Table II shows the results obtained by the use of iron plates one and one-quarter of an inch in thickness, twenty in number, constituting each armature.

Here a gain of four hundred per cent was manifested by the use of thin plates. The next step was to ascertain how many plates were necessary to obtain the maximum effect. The difficulty of obtaining plates of the same homogeneity, made it impossible to obtain smooth curves. To this difficulty was added that of breaking the primary circuit in a regular manner. If the results of Table III are plotted, it will be seen that the increase within small limits, is very nearly proportional to the number of thin plates, which were $\frac{1}{24}$ of an inch in thickness.

TABLE III.

No. of Plates.	Deflection of Galv.	No. of Plates.	Deflection of Galv.
1	11	6	15
2	12	7	15·5
3	13	8	16
4	13	9	18
5	14	10	18·5

On increasing the number of plates a point was reached where there was no additional effect. The best result was obtained when the mass of the armatures was approximately equal to that of the cores of the electro-magnets. Plates of $\frac{1}{32}$ of an inch were also used, but no advantage resulted in their employment over those of $\frac{1}{24}$ of an inch. It would seem that the thin plates followed the same law as that of the bundle of fine iron wires which constitute the cores of induction coils of the present day, and that only a moderate degree of discontinuity in the mass of iron submitted to magnetic influence is necessary to prevent the formation of currents of induction, which prolong the magnetism of the cores, and prevent the quick demagnetization necessary to produce intense currents of induction. The effect of insulating the thin plates with the dielectrics was also tried with no gain in effect. There appeared to be a slight gain by placing the plates edgewise on the poles of the magnets instead of allowing them to repose on their flat faces. This was doubtless due to better contact of the metallic surfaces.

Since the above results proved conclusively a very great gain in quality and electrometric force by the application of thin plates as armatures, I next measured the striking distance of the

spark. Table IV gives the results which are the mean of many trials.

TABLE IV.

Without armatures.	With armatures.
15 cm.	32 cm.
14	30
15	32
Mean, 14·5	31·3

A curious fact came to light in this connection; the lengthening of the spark was not shown when the spark leaped directly between the poles of the induction coil; the increase in quantity and electromotive force, was only made manifest to the eye by the employment of condensers in the secondary circuit. The results in Table IV were obtained by the employment of a leyden jar of large capacity. The increase in the quantity and electromotive force was not only shown by the increased length of the spark, but also by its increase in volume, and its louder snap. The spark consisted of a thick central bolt surrounded by curious thin, detached sparks. An attempt was made to measure the increase of light in the Geissler tubes by Vierodt's photometric apparatus, but it was found too inexact for this purpose; if, indeed there was any increase of light, which remains to be proved. I know of no results which bear upon the relation of the increase of light to the increase of electromotive force of the induction spark. Without condensers in the secondary circuit, however, the increased electromotive force of the spark was shown by its greater constancy in leaping over a given resistance of air.

Unless an instrument is desired for popular scientific lectures, length is not so much to be desired as quantity of electricity of a spark, and in this form of induction coil the gain is principally in quantity, although it is true that with the aid of leyden jars, the striking distance is increased one hundred per cent. The principal points of this paper can be thus summed up:

1. The application of thin plates of soft iron upon the poles of two straight electro-magnets, with bundles of fine iron wires for cores, increases the strength of the spark produced at the poles of the secondary coils surrounding the electro-magnets, four hundred per cent.

2. The length of the spark is increased one hundred per cent. This gain in length is only manifested by the employment of leyden jars of large capacity, which are connected with the secondary circuit.

3. Instead of distributing the fine wire of a Ruhmkorff coil upon a straight electro-magnet, as is done at present, this wire should be distributed equally upon two straight electro-magnets, whose poles should be provided with armatures of bundles of thin plates of soft iron.

ART. XLVI.—*Communications from the Laboratory of Williams College.* No. VI.—*Concerning Phosphorus Oxychloride;* by IRA REMSEN.

THE fact was recently established* that carbon monoxide, though it must be considered as an unsaturated compound, does not readily combine with the oxygen from ozone to form the saturated dioxide. Indeed it was impossible to discover any conditions under which such a combination takes place.

Although it is known that ozone does readily oxydize many substances, it seemed to me desirable to further test its action upon bodies which are generally recognized as unsaturated. For this purpose I have first employed phosphorus trichloride in the hope of obtaining the oxychloride, $POCl_3$. The method of formation of the oxychloride thus indicated would be interesting from more than one stand-point, as will be pointed out below.

It has already been shown by Brodie† that, when oxygen is passed into phosphorus trichloride at the boiling temperature of the latter, a partial transformation into the oxychloride takes place; and Michaelis‡ subsequently showed that this transformation or oxydation is exceedingly incomplete, even though the process be continued for two or three days. An analogous experiment has also been performed by Henry,§ who proved that, when sulphur and phosphorus trichloride are heated together in a sealed tube at 130°, the sulphochloride $PSCl_3$ is formed. It is plain that, in both of these experiments, one of the forces which opposes the combination is that which binds together the atoms of oxygen in the molecule of oxygen, and the atoms of sulphur in the molecule of sulphur; and hence, if we could employ free atoms of oxygen or sulphur instead of their molecules, we would expect the action to take place much more readily. In the case of sulphur, it is not possible, as far as we know at present, to obtain free atoms or unstable molecules which by their breaking up yield free atoms. In ozone, however, we have such an unstable molecule of oxygen. As we have seen in the experiment with carbon monoxide, above referred to, ozone does not always appear to furnish free atoms of oxygen when we might expect it to, and hence the formation of phosphorus oxychloride by the action of ozone could not be predicted with any certainty. Experiment proved, however, that the formation actually does take place with

* This Journal, vol. xi, p. 136.
† Odling's Handbook, i, 297.
‡ Gmelin-Kraut's Handbuch der Chemie, I, i, 391.
§ Berliner Berichte, ii, 638.

great ease, and that phosphorus oxychloride may be obtained in this way in any quantity.

Pure phosphorus terchloride boiling at 77° was placed in a flask. In the cork of the flask were three openings. In one of these was inserted a thermometer which dipped into the liquid; in another was a tube, leading from the ozone-generator, which served to conduct the ozone into the liquid; in the third was placed a tube which in turn was connected with an inverted Liebig's condenser, the latter serving to condense and return to the flask any vapors that might be formed. Oxygen, thoroughly dried by sulphuric acid and calcium chloride, was now passed through the tube which served as ozone-generator. At first I employed a Siemen's ozone-tube which was connected with an induction-coil. The action in this case was not marked, although I soon observed that the thermometer indicated a rise in the temperature of the trichloride. At the beginning of the operation the temperature of the liquid in the flask was the same as that of the air in the room, viz: 15°. In a short time it rose to 36° where it remained stationary, as long as ozone was conducted into the liquid. As soon as the current was stopped, the temperature began to fall and continued to fall gradually until the ordinary temperature was reached.

In about an hour the process was interrupted, and the liquid subjected to distillation. Its boiling point was markedly changed. Only a drop or two passed over before the thermometer indicated 80° and then the mercury rose gradually to 110° when all had passed over. About half the liquid boiled below 90°. This was again subjected to the action of ozone, but now instead of using Siemen's tube, as at first, Wright's tube connected with the Holtz electrical machine was used, and with much better results. The arrangement of the apparatus in this second experiment was the same as in the first. The temperature of the liquid in this case also began to rise as soon as the ozone was passed into it. In a few minutes the thermometer, which at the beginning of the operation indicated 15·5° stood at 44°, where it continued to stand with slight fluctuations during the entire process. At the surface of the liquid the increase in the temperature was so marked, that a portion was converted into vapor, which was returned to the flask by means of the condenser. In the flask, a few drops of a yellowish, resinous material made their appearance, principally at the end of the ozone delivery-tube. The quantity of this substance formed was so small, as to preclude the possibility of an investigation. On repeating the experiment subsequently, this substance always appeared as a product. Whatever it is, it seems to be somewhat volatile with the vapor of the oxychloride of phosphorus.

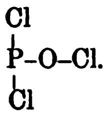
The passage of ozone into the flask was continued for about half an hour in the second experiment, and the product was then examined. About three quarters of the liquid now boiled above 100°, and it did not commence to boil below 85°. By the first distillation it was thus separated into two parts, one boiling below 100°, and the other boiling above 100°. The latter, without further treatment, was at once analyzed. A small quantity was weighed in a sealed bulb, and the bulb then broken under water. After decomposition, pure nitric acid was added and the solution then precipitated with silver nitrate.

0·251 grams of the substance gave 0·6842 grams AgCl= 0·1692 grams Cl.

This corresponds to 67·41 per cent of chlorine, while phosphorus oxychloride contains 69·37 per cent of chlorine and the trichloride 77·4 per cent chlorine. This analysis could hardly be expected to give more satisfactory numbers, as very little precaution was taken to separate the pure oxychloride from the mixture. It proves, however, that the liquid under examination contains markedly less chlorine than the trichloride with which we started, and nearly the same amount as the oxychloride which we would expect to be formed under the circumstances described. The deficit in chlorine may be accounted for by considering the yellow resinous material, above referred to, as being free from chlorine and being also somewhat volatile with the vapors of phosphorus oxychloride.

In addition to the above facts, it was found that the liquid was decomposed slowly by cold water—much less readily than the trichloride—and as a product of the decomposition with water, a large amount of phosphoric acid was formed. Taking then everything into consideration, there cannot be much doubt that, when ozone acts upon phosphorus trichloride, the latter is readily converted into the oxychloride.

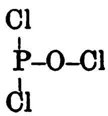
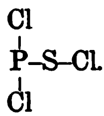
The reaction is analogous to those referred to above, viz: the production of the oxychloride by the action of oxygen upon boiling trichloride, and that of the sulphochloride by the action of sulphur on the trichloride at 130°. Further, it is analogous to the reaction which gives rise to the formation of phosphorus perchloride by the action of chlorine upon the trichloride. The most natural thought that suggests itself is that all these bodies have a constitution similar to that of phosphorus perchloride, and that, in the above reactions, phosphorus passes from the triad to the pentad condition. Those who hold the view that the valence of an element is invariable are inclined to consider phosphorus oxychloride as having a structure essentially different from that of the perchloride, and they write its formula thus:



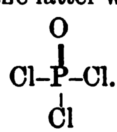
According to this, phosphorus is trivalent in the oxychloride, the same as in the trichloride. The grounds for this assumption are as follows:

1. The oxychloride can be converted into the form of vapor without undergoing decomposition, which shows that it cannot belong to the class of compounds known as molecular compounds, inasmuch as these latter are decomposed into simpler molecules by the action of heat. But, if it is not a molecular compound its structure must be similar to that of phosphorus trichloride, which is the type of the atomic compounds of phosphorus.

2. Thorpe* has recently shown that the specific volume of oxygen in phosphorus oxychloride is 7·89 and that of sulphur in the thiochloride 22·66. These values agree closely with those formerly found by Kopp for oxygen and sulphur which are united with another element with only one affinity each. From this the conclusion is drawn that in phosphorus oxychloride and thiosulphide, the oxygen and sulphur are united to phosphorus by only one affinity each, and hence that the structures of these bodies are represented by the formulas:

 and 

It may be remarked in regard to the former of these grounds that Würtz† has shown that phosphorus perchloride itself, the most decided representative of molecular compounds, may, under proper conditions, be converted into the form of vapor without undergoing decomposition, and hence there is no good reason for assuming that the perchloride differs from ordinary chemical compounds in any essential particular. If, however, the perchloride is a true chemical compound, an atomic in contradistinction from a molecular compound, then phosphorus is in it quinquivalent, while it is certainly trivalent in the trichloride. If, further, we once grant that phosphorus can and does act as a quinquivalent element, we would naturally suppose it to act so in the oxychloride, and hence to the latter would be given the formula,



* Berliner Berichte, viii, 326. † Comptes Rendus, lxxvi, 601.

This formula is more in accordance with known facts than the former one. We can much more readily understand how a compound of this formula may be produced by the action of water on phosphorus perchloride, than we could understand its formation if its formula were

$$\begin{array}{l} \mathrm{Cl} \\ \;| \\ \mathrm{P{-}O{-}Cl.} \\ \;| \\ \mathrm{Cl} \end{array}$$

Thus we have:

$$\begin{array}{c} \mathrm{Cl}\;\;\diagup\mathrm{Cl} \\ | \\ \mathrm{Cl{-}P} \\ | \;\;\diagdown\mathrm{Cl} \\ \mathrm{Cl} \end{array} + \mathrm{H^2O} = \begin{array}{c} \mathrm{Cl} \\ | \\ \mathrm{Cl{-}P{=}O} \\ | \\ \mathrm{Cl} \end{array} + \mathrm{2HCl.}$$

Here the oxygen atom from the water simply takes the place of two chlorine atoms without any further disturbance of the molecule. But, if the formula $\begin{array}{l} \mathrm{Cl} \\ | \\ \mathrm{P{-}O{-}Cl} \\ | \\ \mathrm{Cl} \end{array}$ is correct, then it is plain that the reaction with water is much more complicated. So too the formation of the oxychloride from the trichloride by the action of ozone is much more comprehensible, on the assumption that the reaction consists simply in the taking up of an atom of oxygen, without any accompanying displacement and subsequent binding of chlorine.

In regard to the experiments of Thorpe, it may be said that, if Kopp's principle is correct, i. e., if the specific volume of an atom is determined by the manner in which it is held in combination, and, if Thorpe's numbers are correct, then there can be no doubt that the conclusion drawn by him is also correct. While there is no reason for doubting the correctness of the numbers obtained by Thorpe, we may perhaps be justified in not accepting Kopp's principle as so firmly established, that we can employ it as a means of proving the correctness or incorrectness of formulas which seem to be well established by other means.

March, 1876.

ART. XLV.—*On additional species of Fossils from the Primordial of Troy and Lansingburgh, Rensselaer County, N. Y.;* by S. W. FORD.

IN a paper communicated to this Journal about a year ago (March, 1875) I gave a short account of the Primordial rocks in the neighborhood of Lansingburgh, N. Y., and of the finding of several species of fossils in a deposit of conglomerate lime-

stone occurring there. I had hoped to be able to devote a good deal of time to the further study of this field during the past season, but other matters prevented, and while I have made a number of additional observations upon the structure of the region, I am not, as yet, prepared to place them upon record.

From the conglomerate-limestone* I have, however, made collections on several different occasions and with very gratifying results. The following is a list of the species known to me from this deposit at the present time, all of which have been obtained from the rock in place: (1) *Olenellus asaphoides*, (2) *Conocephalites trilineatus*, (3) *Microdiscus speciosus*, (4) *Hyolithes Americanus*, (5) *H. impar*, (6) *Hyolithellus micans*,† (7) *Stenotheca rugosa*, (8) *Obolella desquamata*, (9) *O. nitida*. Of these 2, 4 and 9 were known from this deposit at the time of publication of my former paper. All of these species occur likewise in the Lower Potsdam limestones at Troy. This gives nine species in common to the two localities and is, I believe, conclusive as to the age of the conglomerate in question. I have no doubt but that, when further studied, this rock will furnish yet other species of the Troy series.

Fossils from the Primordial at Troy.—For a long time my examinations of the slates at Troy for fossils were unrewarded, notwithstanding I gave a good deal of attention to the subject. But on one occasion last summer I succeeded in finding several slabs containing undoubted plant remains. There appear to be two or three species. Of these, however, but one is represented in the collection by specimens sufficiently well preserved to admit of anything like a satisfactory determination. This is of the genus *Palæophycus*, and is, according to Mr. Billings, to whom I have lately submitted my specimens for comparison, perfectly identical with his *Palæophycus incipiens* (Pal. Fos., vol. i, p. 2), from rocks of the same age in Vermont and on the north shore of the Straits of Belle Isle in Labrador. The principal specimen in my collection is six inches long, nearly straight, of uniform width and without any evidences of branching. On the same slab there are several shorter fragments. This adds a

* This rock is of other than paleontological interest. I have recently ascertained that good typical specimens of it are susceptible of a fine polish. The limestone fragments of which it is principally composed are, for the most part, of a dark blue color, compact and of a flint-like fracture, and, in polished sections, contrast finely with the yellowish calcareo-arenaceous matrix in which they seem almost to float. Along with these are lighter colored, less coherent fragments in which the fossils mostly occur. It has been quarried to a considerable extent for building purposes, and appears to be a good durable stone. There is a bridge on the Troy and Boston R. R. in the village of Lansingburgh composed of it.

† Mr. C. F. McMurray of Lansingburgh, and a graduate of Yale College, who accompanied me on one of my excursions, has recently presented me with a specimen of an unusually large individual of this species, collected by him subsequently on the occasion of an independent visit made to the locality.

new class of fossils to the Troy fauna, and gives us, moreover, another example of a fossil species having an extensive geographical range.

It occurs in the coarse red-and-yellow-weathering slates of the Lower Potsdam group at Troy.

During the past season I paid a large number of visits to the first band of limestone met with in going eastward from Troy, and which, in a former paper, I have characterized as limestone band No. 1. (This Journal, Aug., 1873) As the result of this I succeeded in obtaining several species of fossils not previously known from this band, although known to occur in the other limestone beds of the Troy Primordial, and along with these a single head of a new and very pretty Trilobite of the genus *Microdiscus*. This I shall describe for the present as follows: Head, broadly rounded in front, nearly semi-oval in outline, greatest width at about the mid-length, slightly narrowed in passing backward from this point to the angles. Glabella conical, about two-thirds the length of the head, with two straight, moderately deep furrows extending all across, dividing the glabella in advance of the neck-furrow, into three parts of nearly equal length. Neck-furrow extending all across and deeper than the other glabellar furrows. The form of the neck segment cannot be clearly made out owing to the damaged condition of the specimen at this point. Dorsal furrows narrow, not deep, dying out toward the front of the glabella. Cheeks prominent, much swollen in the posterior third, without eyes or sutures. Marginal rim well defined all around, widest in front, with a conspicuously raised edge, inside of which there is a nearly flat or feebly concave space, and so bent upward in front as to give to the head on a side view a kind of slipper-like appearance On either side of the head, just inside of the raised marginal edge, there are three small tubercles situated within the limits formed by a line drawn across the head through the middle of the cheeks and another drawn parallel with it just in advance of the front of the glabella.

Greatest width of the head 1⅓ lines; length along the median line, including the neck-segment, the same. Differs from *Microdiscus* (*Agnostus*) *lobatus* Hall (Pal. N. Y., vol. i, p. 258, pl. lxvii, figs. 5 a–f), from the same locality, in its shorter and transversely furrowed glabella, its tuberculated margin, and in its general proportions.

For this species I propose the name *Microdiscus Meeki*, in honor of Mr. F. B. Meek, whose labors in the cause of science have so vastly contributed to advance our knowledge of American Paleontology.

Occurs in conglomerate limestone of the Lower Potsdam group at Troy.

Troy, N. Y., Jan. 15, 1876.

ART. XLVI.—*On a simple and very accurate method of tuning two Forks to unison;* by ROBERT SPICE, F.C.S.

THOUGH the optical method of tuning, of Lissajous, gives good results, I find that two forks thus tuned to unison, may be a *fraction* of a vibration *out*, without in *any way* disturbing the steadiness of the figure.

In the 2d edition (English) of Tyndall's "Sound," in lecture VII, the author says, "I divide this jar by a vertical diaphragm, and bring one of the forks over one of its halves, and the other fork over the other. The two semi-cylinders of air produce beats by their interference. On removing the diaphragm, the beats continue as loud as before, one half of the same column of air interfering with the other."

Dr. Tyndall does not, however, mention the fact, that precisely the same result would have been obtained if no diaphragm had been employed, yet this is so. When two unison forks are struck on the knee, (or by a piece of lead covered with leather,) and then held *together* over their proper resonant column, the following phenomena will be observed.

If there is a difference between their rates, of several vibrations, there will of course be rapid beats; if the forks are *very* nearly in tune, the beats will succeed each other at long intervals; further, when they are *almost* perfectly in tune, there will not be any beats properly so called, but after the sound of the forks has *nearly* died away, it will rise or swell out again *very slightly*, proving that there had been interference.

Finally, when the forks are absolutely alike, there will be a gradual decrease of sound, down to silence, without any reinforcement at any time.

I find that to carry out this tuning absolutely, both forks must be at the same temperature; consequently, after using a file on one of them, I place both forks in a vessel of water to equalize their temperatures, wipe them dry, and test them. To show the accuracy of this method I select the following example:

A pair of Ut^3 forks (256 vibrations) will sound over a column for about 135 seconds; suppose that the sound decreases up to the 100th second, and then begins to rise; obviously 100 seconds is the time of *half a beat*, or 200 seconds the beating time; that is to say, it will have been demonstrated that one of the forks gave $\frac{1}{200}$ of a vibration *per second* more than its fellow.

What has been said of the unison, applies to other intervals.

I have recently executed by this method, Ut_4, Ut_5, Ut_6 and Ut_7 forks for the physical cabinet of Columbia College.

230 Bridge Street, Brooklyn, Jan., 1876.

ART. XLVII.—*Silica of grasses and other plants carried up as Diatoms or other siliceous grains, and not in solution or as soluble silicates;* by Prof. P. B. WILSON.

MY attention was called, some time since, in the examination of the ash of plants obtained by slow incineration in a platinum crucible, to the fact that when the ash is treated with dilute acid, and evaporated to dryness on the water bath, it does not pass into the gelatinous condition prior to complete decomposition of the *hydrated* mass, as is the case with the silicates soluble in acid, or those decomposed with sodium and potassium carbonates. If, however, the ash, prior to the treatment with acid, is subjected to a high temperature, a combination of silicic acid with the alkalies, the alkaline earths, and the earths takes place, if all are present; then the silica separates in the gelatinous form and presents all of the chemical reactions of silicic acid obtained from the natural silicates. The silica obtained from ash by either of the processes indicated, on close examination, was observed to be entirely free from any combination, showing that it had been assimilated in the free state.

To demonstrate this theory, my friend G. I. Popplein, Esq., of this city, suggested the application of infusorial earth of the Richmond formation—found in large quantities on the western shore of the Chesapeake bay—to land sown in wheat. I have obtained straw from wheat so grown, and have found, after it has been treated with nitric acid, and the siliceous remains placed on the field of the microscope, that it consisted wholly of the siliceous shields of Diatomaceæ, the same as found in the infusorial earth, excepting that the larger discs in their perfect form were absent (*Actinocyclus Ehrenbergii* and *Actinoptychus undulatus*). My conclusions are that they, and there probably may be other forms, are too large to enter the root capillaries. During the coming summer I will attempt if possible to make micrometer measurements of both.

The discovery of Diatomaceæ in their original form in this wheat straw precludes the possibility of the infusorial earth having undergone any chemical change in the soil, either by forming chemical combination with the alkalies, or the earths, or by suffering physical disintegration from any catalytic action of any salts present in the soil

In the particles of silica placed upon the glass slide, when they were completely separated from each other, the outlines of the individual diatoms were sharply and distinctly defined. On the other hand, when the physical action of ebullition with nitric acid was not sufficient for the complete separation of the

particles of the epidermal shield, there was observed a marvelous interlacing of the various forms, showing that they were conveyed by the sap cells directly to the section of the plant where they were destined to complete its structure. I have examined several specimens of straw, taken at random in the market; the silica in each specimen consisted of plates, very thin, and truncated at the corners.

The result of these investigations shows the necessity of finely divided silica in the soil, so minute as to be capable of passing with facility through the sap cells; secondly, that simple or compound silicates are useless as fertilizing agents, either natural, or artificially prepared. We have no valid reason for forming any theory that vegetation can, through any known chemical law, separate the elements or their compounds from combinations so positive in their character.

In this case we have a practical result capable of being verified at any stage of growth of a plant, produced by the application of silica to the soil in the form of certain well defined microscopic organisms; for, finding these in the ash to the exclusion of other particles of silica, they seem to be more acceptable for the plant structure. Free silica is hence the only condition in which it can enter the plant.

I look upon this discovery as leading agricultural investigations in a new direction, and it must eventually change many of the views expressed and accepted by scientists.

Every precaution was used in having all the material thoroughly cleansed, with a view both for accuracy and for removing suspicions that these microscopic forms were the result of dust showers.

Washington University, Medical department, Baltimore, Md., February, 1876.

ART. XLVIII.—*The Conglomerate Series of West Virginia;* by WILLIAM M. FONTAINE.

[Concluded from page 284.]

DR. STEVENSON, in his "Notes on the Geology of West Virginia," (read before the Am. Phil. Soc., Feb. 5, 1875,) speaks as follows of the "Great Conglomerate" of Randolph county. "This rock forms the crest of Rich Mountain for nearly sixteen miles within the region examined. For the most part it is a coarse sandstone, loaded with pebbles from one third of an inch to two inches in diameter. Along the Staunton Pike it shows some layers of slightly micaceous and very compact sandstone near the bottom. Here it is greatly increased in thickness; near the northern line of the state it is barely 350 feet thick, but in Randolph county it is not less than 600." He further says, "On the

Staunton Pike, along the east slope of the mountain, there was seen midway in the conglomerate, what appeared to be the blossom of a coal bed. As I had observed no evidences of coal in the conglomerate northward from this locality, this exposure was studied with some care, but nothing definite could be ascertained. Six miles farther south, on the same side of the mountain, a small coal bed occupies this place on the property of Mr. Bradley. There it is three feet thick." Dr. Stevenson also points out the mistake made both by himself, and myself, in admitting the presence of coal in the conglomerate of Monongahela county.

Dr. Newberry has shown that the Sharon coals of Pennsylvania, which are in the reports of the first survey put under the conglomerate, are really of later age. There remains then no case where coals are found within the rock in its extension northward.* As is well known, the conglomerate in Pennsylvania north of this part of West Virginia, has thinned down to a homogeneous rock of 100 feet and less. We must then look for the north extremity of the special basin in which the expansion of this rock took place, somewhere in Randolph county. In farther confirmation of this, Dr. Stevenson mentions the curious fact that in that county the upper Umbral shales, at one point, thin out entirely, and the conglomerate is in contact with the limestone.

In Ohio, the reports of that State show that the conglomerate has become too thin to form a continuous stratum.

Proceeding southwest, from Ohio into Kentucky, we find the conglomerate series forming the west outcrop of the east Kentucky coal field, being the sub-conglomerate coals of that State. Mr. Joseph Lesley, (Proc. Am. Phil. Soc., No. 91,) in his account of this outcrop belt, shows that in that quarter the Umbral shales are entirely wanting, and that the coals under the conglomerate lie immediately on the sub-carboniferous limestone. He traces this outcrop from Carter county southwest to Clinton county, on the south border of the State. The thickening of the series in that direction shows plainly that his line of investigation diverged from the edge of the basin and approached nearer and nearer toward the central portions. He states that the series consists of two members, the upper one a conglomeratic sandstone, and the lower one a coal-bearing portion. The upper member thins in proceeding southwest, while the lower

* If Professor Tyson's section of the Cumberland basin be correct, then it is clear that northeast of Randolph Co., in Maryland, the conglomerate again has coal in its central portion. He gives on Savage River, above the Umbral shales, and including the so-called "Coal-Measure Conglomerate," a thickness of 451 feet. In this space he places three coal beds, two feet, two feet six inches, and two feet thick. The entire mass is begun and ended with massive sandstones, having a similar structure to the New River field.

member thickens at a more rapid rate. At Grayson, in Carter county, both together are only 90 feet thick, and the lowest coal is a mere streak formed between the base of the formation and the underlying limestone. Farther southwest, in Morgan county, the upper member is 150 feet thick, and the lower member only eight feet, and contains a twelve-inch bed of coal. In Estell county, the upper member measures 200 feet and the lower fifty feet, with the coal bed increased to twenty-seven inches. On the southern border of the State, the lower member increases to 225 feet, and contains two workable and three other thin beds of coal. The upper member does not now exceed eighty feet. This upper member is No. 21 of the Raleigh section.

Passing into Tennessee, we learn from Safford that the western outcrop presents the same essential features as in Kentucky. The red rocks of the Umbral are wanting, and the coal system rests on the sub-carboniferous limestone. But in Tennessee the thickness attained on the south border of Kentucky does not seem to be maintained in the counties immediately south of that point. Here also along the west outcrop in Fentress, White, and Franklin counties, the series is double, consisting of an upper sandstone and a lower coal-bearing portion. Of this latter Safford says, "It consists of shales and sandstones, the latter sometimes absent, and ranges from a few feet to about 200." It contains two, sometimes three, rarely more, seams of coal. These are often too thin for mining, but locally swell out and form valuable deposits, from two and a half to four or five feet in thickness."

This thinning out in the direction immediately south of Clinton county, Kentucky, seems to indicate that in Tennessee the west end of the basin sweeps around more to the south. Safford's sections show that these rocks increase in thickness from west to east with an increase of the sandstones, while the coals diminish greatly in the most easterly portions of the field; for while the west outcrop has the character above given, we find at the Ætna mines, a point farther east, a thickness of 563 feet, including the upper conglomerate, and at Lookout Mountain, the most easterly point of the sections given in the southern part of the field, we have 673 feet, composed mainly of coarse sandstone, with hardly any coal. This diminution of coal eastward agrees with the facts given by Professor J. P. Lesley for Wise, Russel, and Tazewell counties, Virginia.

One of the most striking points of difference between the strata shown on New River, West Virginia, and the west outcrop, is the disappearance in the latter of the thick deposits of the red Umbral shales underlying the conglomerate series in West Virginia. This is explained by the fact that these sediments are derived from the incoherent red shales, so abundant

in the upper Devonian of the Alleghany region on the east border of the basin. In this upper Devonian we find abundant red shales, which in physical character cannot be distinguished from those of the Umbral. None such are found in the Cincinnati anticlinal on the west border. It would also seem from what has been given above, that the quarter from which the greatest part of the sediment came, was the east, while the coals grew from the west.

If we may draw any conclusions from the data given above, we may believe that the coal-bearing rocks accompanying the conglomerate were formed in a comparatively restricted basin, which commenced in the northeast corner of Alabama, and extended as far northeast as Randolph County, West Virginia. Its deepest part was probably along a northeast line which passes east of the Cumberland Mountains, and crosses New River near the center of Raleigh County. The strata occupying the interval between the Devonian and the lowest of the "Lower Productive Coals" are on New River in this region at least 4,200 feet thick. It is highly probable that the formation of this deep narrow trough caused that intense strain in the crust of the earth which finally resulted in the production of that wonderful system of faults which is found on the east border of the coal-bearing strata described above, and which seems to be mainly developed along this border near the deepest part of the depression.

As to the character of the coal found on New River, in the series in question, it is a semi-bituminous coal, a fair example of which may be found in the seam mined and coked at Quinnimont. An analysis of this seam furnished me by Mr. Morris, shows the following: Carbon 75·89; vol. matter 18·19; ash 4·98; water ·74. The coke contains: Carbon 93·85; ash 6·15; sulphur ·23. This small amount of bituminous matter is noteworthy when we consider the undisturbed condition of the coal beds. This disturbance is no greater than that found in the highly bituminous coals of later age in other parts of the State. We must explain this loss of volatile matter in some other way than by mechanical action.

Plants.—There are only two horizons which have yielded me plants. These are the Quinnimont coal seam, or coal No. 9, and coal No. 5, or No. 14 of the Piney River section. At the locality which I shall give as horizon of coal 5, Quinnimont, this coal bed does not show, owing to the imperfect exposure, but the shales containing the plants occur at the horizon of coal 5.

I cannot pretend to have made anything like an exhaustive search for plants, even at these horizons. I made my explorations on foot, armed only with a small hammer and satchel as the implements for procuring and transporting specimens. On

the Raleigh road, and at the locality at Quinnimont, all my material was obtained from the weathered outcrop of the plant-bearing shales. In my second visit to the locality at Sewell Station I was in hopes of making large additions to my stock of the interesting plants found there on a former occasion. I was led to entertain this hope from the fact that in my previous visit I spent only an hour or two in the collection of the plants. But I found on my second visit that the impressions were restricted to a very thin layer in the roof, and that from the small amount of material on the "Dump" but little in addition could be obtained. The opening was inaccessible, being filled with water. It is an interesting fact regarding most of the plants found here, especially the *Megalopteris*, that they were seen nowhere else. The locality on the Raleigh road of the Piney River section, is a very promising one, affording a number of good specimens, in the weathered outcrop.

The following are the plants obtained from this series; some of them were procured in my first visit and were noticed in my former paper.

1. *Sphenopteris Hœninghausi* Brongt. Quite common in large and beautiful specimens with coal No. 5, Raleigh County.

2. *Calamites Rœmeri?* Göpp. Fragments resembling this calamite more closely than any other, were found with coal No. 9, at Sewell Station.

3. *Lepidodendron Selaginoides* Sternb. Good impressions of the bark and leafy branches, are not uncommon with coal No. 5, Raleigh County. I found associated with this plant very small leafy branches closely resembling the figures by Lesquereux, of *Lycopodites Meekii.* They are no doubt small branches of *S. Selaginoides.*

4. *Sphenopteris Adiantoides* Lindl. and Hutt. A single specimen but well marked, was found with coal 5, Raleigh County.

5. *Bornia radiata* Brongt. Found with coal 9, at Sewell Station, and coal 5, Raleigh County.

6. *Odontopteris gracillima* Newb. A single pinnule was found at Sewell Station with coal 9.

7. *Neuropteris, species?* Of this plant I have some detached pinnules, and one pinna with five pinnules, not enough for positive determination. It was obtained at Sewell Station from coal No. 9. The following features are shown in the specimens obtained: Fronds bipinnate; pinnules placed obliquely, and remotely; attached by the central portion of the base; subalternate, 2½ cm. long, 8 mm. wide, margin strongly repand, oblong lanceolate, acute, upper portion of the base rounded obliquely, lower portion forming a short round lobe, midrib slender, but strongly defined, diminishing in size, and near the end, splitting up into nervules, rather flexuous. Side nerves

closely placed, leaving the midrib at a very acute angle, strongly arched so as to meet the sides at a right angle and forking repeatedly.

This plant so far as can be gathered from the imperfect specimens obtained, is of the same type with the *Alethopteris obscura* of the Pennsylvania reports. Fig. 13 of these reports would give a good representation of it if the pinnules were separate to the base, more remote, and inserted on the rachis as above described. The nervation is the principal point of difference. It will be noted that this plant has many features in common with the Mesozoic *alethopterids*.

8. *Cordaites Robbii* Dawson? This plant is rather rare and occurs at Sewell Station with coal 9, and at Quinnimont at the horizon of coal 5.

9. *Alethopteris Serlii?* Brongt. This plant, which is the most abundant one in coal 9 at Sewell Station, differs in some points from *A. Serlii.* The pinnules are more slender, and are decurrent by their lower base which forms a narrow wing, while the upper portion of the base is obliquely cut away so as to cause the midrib to spring from the upper margin, which is barely reached by the decurrent portion of the pinnule next above. The pinnules are usually strongly recurved. In these points it resembles Dawson's *A. discrepans* of the Devonian. It may be a new species.

10. *Calamites cannæformis* Schloth. This is not rare in the slates over coal No. 9, at Quinnimont.

11. *Alethopteris grandifolia* Newb. This plant which is common at the horizon of coal 5 at Quinnimont, at first sight of the upper entire pinnules, resembles No. 9, but in its nervation, which more resembles that of *Neuropteris*, and in other points, it is very different, I have placed this under *Alethopteris grandifolia* from which it is somewhat different, for the same reason that I included No. 9 under *A. Serlii*, being unwilling, without more abundant material, to place these plants apart. The forms of No. 11 seem all to come from the upper part of the frond, and belong to the broad leaved variety of *A. grandifolia*, if they are identical with it. They represent the terminations of fronds or compound pinnæ, showing in their lower parts, pinnæ pinnately cut into pinnules, which become more and more united toward the summit of the frond or pinna; changing first to pinnules, with deeply undulated margins, and finally passing into pinnules with entire borders. These closely resemble the broad leaved variety of *A. grandifolia*, but are relatively narrower, and less united at the base. In their mode of insertion, they resemble to a certain extent No. 9, being somewhat cut away above and decurrent below. In No. 9 the nervation is that of *A. Serlii*, while in the plant in question it

resembles somewhat that of a *Neuropteris* in the fact that the side nerves spring obliquely from the midrib, fork two or three times and curve strongly to meet the margins. The nervation is like that of No. 7, but in the insertion of the pinnules by the entire base, in their decurrence, and other points, this is a true *Alethopteris.*

12. *Neuropteris Lindleyana* Sternb. *Var.* This beautiful *Neuropteris* is common at Sewell Station, where it forms the only plant found at the horizon of coal 5. It also occurs with this coal, in the Piney River section, on the Raleigh road. While in the main point it clearly resembles *N. Lindleyana*, figured in the Fossil Flora of Great Britain, as *N. Löschi*, there are some points of difference. Our plant has not the same degree of sharpness in the terminations of the upper simple pinnæ, and these are not so much narrowed at the base. Again the rounded pinnules of the lower compound pinnæ have a much more slender midrib than that indicated in the figure of the British plant. They are also more closely placed. In the greater bluntness of the upper simple pinnæ, and in their nearer approach to a heart-shaped base, this plant approaches nearer to *N. Loschi*, but it is very different, and may perhaps be best considered as a variety of *N. Lindleyana*.

13. *Neuropteris tenuifolia* Schloth. Found with coal 5 on the Raleigh road, apparently rare.

14. *Sphenopteris, species?* This plant was found with coal 5 on the Raleigh road. The fragments found do not enable me to determine it satisfactorily. It belongs to the Schimper's section, *Sphenopteris cheilanthides.* It is in some respects like *S. Dubuissonis*, but differs in others. The following features are shown in the fragments obtained: Pinnæ oval lanceolate, placed alternately at right angles on the rachis. Pinnules obliquely and alternately placed on the secondary rachis which at the base is narrowly winged and from which they diverge; oblong, narrowing considerably to the summit, and slightly so at the insertion of the base, where they are decurrent. The pinnules diminish rapidly in size from the base to the apex of the pinnæ. At the base they are one cm. long and four mm. wide. The pinnules of the base of the pinnæ are cut obliquely into three oval tooth-shaped lobes on a side, which are remotely placed, and diverge slightly from the midrib. In ascending, the number of the lobes and the depth of their incision diminishes until the pinnules become entire, when they are very small and mere lobes of the wing of the rachis, which at the extremity of the pinnæ is much widened. The plant seems to have leaflets of leather-like consistency; the nervation is obscure.

15. *Sphenopteris, species?* This plant, which is not uncommon with coal 5 on the Raleigh road, has a strong resemblance to

Sphenopteris Newberryi, but shows some features not seen in the figure of that plant given in the Pennsylvania reports. From a study of the isolated fragments, in which form alone I could get it, the plant shows the following features: The pinnules of the lower pinnæ have the form of those similarly placed in *S. Newberryi*, but are proportionally narrower at the base, distinctly separate, and more obliquely placed. In ascending, the pinnules of the upper pinnæ are finally reduced to circular segments of the laminæ of the pinnæ, and now if seen apart would be taken to belong to a different plant. These upper pinnæ are placed obliquely and alternately. They are ovate lanceolate, 12 mm. long and 6 broad at base; having the general shape and mode of incision shown in *S. decipiens* of the Pennsylvania reports. But unlike that, the termination of the pinnæ is prolonged into an acute point. Proceeding still higher on the frond, these pinnæ are reduced to semicircular lobes of the broad wing of the rachis which now forms the entire lamina of the upper part of the frond or compound pinna. The nerves are to a great extent masked by the thick leathery character of the leaflets, but, so far as mode out, are as follows: In the lower distinct pinnules there is a strong midrib which disappears before reaching the extremity of the pinnule, and gives it at first sight the appearance of a *Pecopteris*. The side nerves spring very obliquely from the midrib, diverge very slowly from it, curving gently out to the margin, and fork once or twice, being quite distant from each other. In the rounded lobes of the upper pinnae, the nerves rise from the whole base of the lobe curving gently outward, and downward, while forking as before. Here the nervation resembles that of *S. dilatata* as figured in the Fossil Flora of Great Britain. The same nervation marks the extremity of the frond. The most characteristic feature is the rarity of the nerves, and if the plant should prove to be new, would justify the specific name *varinervis*.

16. *Hymenophyllites spinosus* Göpp.? Fragments were found on the Raleigh road with coal 5, of a plant showing the basal portion of several pinnæ, which seem to be identical with the above named plant. Not enough material was obtanied to identify it with certainty.

17. *Sphenopteris macilenta* Lindl. and Hutt. This plant seems to be abundant on the Raleigh road, associated with coal 5. Good specimens were obtained.

18. *Equisetites, species?* A single sheath, resembling that of an equisetites, was found on the Raleigh road with coal 5.

19. *Asterophyllites acicularis* Daws.? A specimen showing several whorls of leaves having the character of the above named plant, was obtained from coal 5 on the Raleigh road. Not enough is shown for positive identification.

20. *Trigonocarpon triloculare* Hildreth. A single nut was found at Sewell Station with coal 9. A nut of a different character from any figured or described to my knowledge, was found at the horizon of coal 5 at Quinnimont. It is perfectly smooth with no markings, is about 12 mm. long and 5 mm. wide, cylindrical in shape, and bluntly rounded at the ends, one of which is furnished with curved stem-like appendages, as if for attachment. Nuts are quite rare, only these two being found.

21. *Megalopteris Hartii* Andr. In my last visit to the plant locality at Sewell Station, which furnished me on my former visit the specimens of *Megalopteris*, and which is coal in 9, I procured a few additional specimens of this plant, among which, by comparison with the plates which Professor Andrews has had the kindness to send me, I recognized his *M. Hartii.* Of this plant I have one specimen having the ends of the two leaves at the summit of the frond, showing about six inches of their length. Another specimen shows the termination of a much smaller frond, with three leaves. Along with these leaves I find several of a small *Megalopteris* which may prove a different species although the nervation, so far as it can be made out in the obscure state of all the plants found here, seems to be very near that of *M. Hartii.* Of the small plant, no more than two leaves together have ever been found, and no specimen shows the point of junction of these. The small size seems to be a constant feature. Such leaves are about 6 cm. long and 1 cm. wide; they are narrowly elliptical in shape, with a rather more acute termination than that of *M. Hartii.* The midrib seems to have been large for a leaf of this size, and very prominent. It leaves a deep rectangular impression.

22. *Megalopteris, species?* This plant is the most common form found at Sewell Station. It differs from all the forms of Professor Andrews' plants figured in the decided acuteness of the leaves or pinnules; in which respect it is more like *M. Dawsoni.* From this latter plant it differs in the more decided elliptical outline of the leaves, the more rapid narrowing of the leaves toward their extremities, and most of all, in the nervation, which so far as can be made out, is near that of *M. Hartii*, being fine, from closely placed slender nerves, which fork near the base and again near their middle; apparently, higher up, than in *M. Hartii.* The nerves are nearly parallel in their course; and curve very slowly outward to meet the border of the leaf. I have one specimen which shows one entire leaflet, and the base of another, which diverges from the rachis at the base of the first, showing the ordinary alternate arrangement on a winged rachis, of the leaflets in plants of this genus. The entire leaflet of the specimen, is 14 cm. long, and 2½ to 3 cm. wide. It is strongly

narrowed toward the base, giving it an oblanceolate shape. Near the extremity, it is rapidly narrowed to an acute point. It is most probably a new species, and if so, might receive the specific name *Sewellensis*.

23. *Sphenopteris obtusiloba* Brongt. Found rarely at Sewell Station, with coal No. 9.

24. *Palæopteris Jacksoni* Schimp. *Cyclopteris Jacksoni* Daws. Only one or two small fragments of this plant, were found at Sewell Station with coal 9.

25. *Sphenophyllum antiquum* Daws. A small fragment only was found at Sewell Station with coal 9.

26. *Odontopteris Neuropteroides* Newb. Good specimens of this plant were obtained from the horizon of coal No 5 at Quinnimont, where with the variety of *Alethopteris grandifolia*, it forms the most abundant plant. Some pinnules show an obscure lobing not unlike some of the pinnules of *Sphenopteris Lesquereuxii*. Some scattered broad pinnules, with undulating borders, were found here which, from their appearance, would seem to have belonged to some part of this plant.

27. *Calamites approximatus* Schloth. Found at Sewell Station, with coal No. 9.

The plants above named, with the exception of the few got from Sewell Station previously, and mentioned in my former paper, were all obtained in my last visit to the New River region. As I stated before, this list can by no means be taken as exhaustive of the plants, even at the locality where they were gathered. In no case could I spend more than a couple of hours in collecting, and, having no tools, my collection was made by picking up fragments fallen from the disintegrated outcrop. This was the case with the coal on the Raleigh road, which furnished so many of the above specimens.

The following fossils were obtained from near the top of No. 1 of the transition beds at Quinnimont and consequently just from the base of the conglomerate series. They were kindly determined for me by Dr. J. J. Stevenson. He states that in most cases they were too badly preserved for specific determination.

Invertebrate fossils from the base of the Conglomerate Series at Quinnimont.

1. *Productus cora* D'Orb.	6. *Myalina*.
2. *Athyris* sp.	7. *Macrodon*.
3. *Spirifera Leidyi* N. & P.	8. *Lithophaga*.
4. *Aviculopecten*.	9. *Chænomya?*
5. *Lima*.	10. *Fenestella*.

Of these Dr. Stevenson states that the *Macrodon* is a new species, which also occurs commonly in the middle portion of the

Umbral limestone in Monongalia Co., W. Va. He thinks that the *Myalina* and *Chœnomya* are new species. Also that the *Lithophaga* is so near that referred with doubt to *L. lingualis* of Phillips, by M. & W., that he cannot distinguish it, although this is a species of the St. Louis group.

I may state here that the *Palæopteris Jacksoni* of the Conglomerate series, is the typical plant, and very different from the plant found at Lewis Tunnel, and given in my previous paper as *P. Jacksoni.* I have additional specimens from Lewis Tunnel, which show without doubt that, as Professor Andrews has suggested, this latter is a new species.

It will be seen from the above, that the representatives of the Devonian flora of Canada are quite common in the Conglomerate Series. The uppermost strata of the Devonian in West Virginia are at least 3500 feet below coal 5; and still farther below coal 9, which affords the plants of most decided Devonian type. Besides, the forms of *Megalopteris*, the *Palæopteris*, and *Sphenophyllum*, we have probably *Asterophyllites acicularis*, and *Cordaites Robbii*, identical with the Devonian plants. The *Cordaites* has the nervation and termination of the leaves of *C. Robbii*, but I mark it doubtful, as I have no entire leaves. The *Sphenopteris adiantorides*, is a good deal like the plant figured as *Cyclopteris obtusa*, by Dawson in the Acadian Geology, although smaller. The plant marked doubtfully *Alethopteris Serlii*, is very near *A. discrepans.* The *Sphenopteris* allied to *S. Newberryi*, in its upper pinnæ shows the mode of lobing, and has something of the aspect of *S. marginata.*

It will be noted that along with these plants we have some of the forms found in coal No. 1 of Ohio. The upper pinnæ of the plant identified with *Sphenopteris macilenta* I cannot distinguish from Dawson's *Cyclopteris valida.* Besides these, we have plants first found in Felling Colliery, England, associated with the "Low Main coal seam."

ART. XLIX.—*Mineralogical Notes;* by EDWARD S. DANA. No. III.—*On new twins of Staurolite and Pyrrhotite.*

1. ON STAUROLITE CRYSTALS FROM FANNIN CO., GEORGIA.

THROUGH the instrumentality of Prof. F. H. Bradley a large number of staurolite crystals have been recently received in New Haven, some of which show forms which are new and interesting. Prof. Bradley mentions two distinct localities, visited by him, which afford the staurolite in considerable quantities. The first is at Valley River, near Murphy, Cherokee Co., North Carolina. The crystals at this place are large

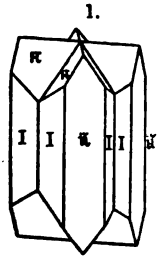
and coarse. They occur in a metamorphic rock which Prof. Bradley states belongs to the Cincinnati group.

The second locality is in Fannin Co., Georgia, 12 miles southeast of Ducktown, Tenn. The crystals obtained here are of quite uniform size, averaging an inch in length, and are very perfectly developed, the faces being smooth, though usually without polish. They occur in a soft mica schist, belonging geologically, according to the same authority, at the base of the Quebec Group. The rock is extensively decomposed so that the crystals are found abundantly loose on the surface of the ground. Large quantities of them may thus be picked up, of which perhaps one-tenth are perfect crystals. They are in general nearly free from the gangue.

The crystals are with rare exceptions twins. The most common twins are those well known in this species; that is, (*a*), those having the composition face $\frac{3}{2}$-$\breve{i}$, with the vertical axes nearly at right angles to each other; and (*b*), those having the composition-face $\frac{3}{2}$-$\breve{\frac{3}{2}}$, with the vertical axes crossing at a angle of about 60°. Under these two types there is a very wide diversity of form arising from the extension or partial suppression of various of the occurring planes. A very common feature in the twins of the first kind mentioned is the almost entire suppression of one pair of the macrodome planes 1-$\bar{i}$, opposite each other, with the corresponding extension of the other pair; this same kind of hemihedral development is also extended to the prismatic planes giving rise to forms of very oblique appearance.

Three new forms are shown in figures 1, 2 and 3. Figure 1 exhibits a new method of twinning not before observed in this

1.



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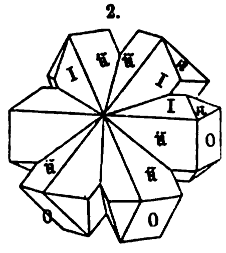

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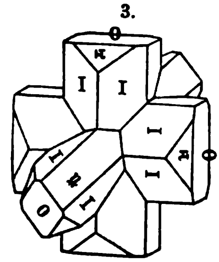


species, and making the third type of penetration twins peculiar to staurolite. The measured angle of the two brachypinacoids (i-$\breve{i}$) for the crystals in their twinning position is 70° 30′. This gives for the composition-face i-$\breve{3}$, which requires for the above angle 70° 18′. In this case the axis of revolution very nearly coincides with the plane i-$\breve{\frac{3}{2}}$ and the i-$\breve{i}$, of the second individual is very nearly parallel to the prism I of the first. Attention has been called, by Prof. Dana, to the fact that if the

occurring prism on staurolite be made $i\text{-}\frac{3}{2}$, the twinning planes will be then planes of simple axial ratios in accordance with the usual law, namely $1\text{-}\breve{i}$ (instead of $\frac{3}{2}\text{-}\breve{i}$) and 1 (instead of $\frac{3}{2}\text{-}\breve{\frac{3}{2}}$). The new method of twinning here described would then have for its composition-face $i\text{-}\breve{2}$.

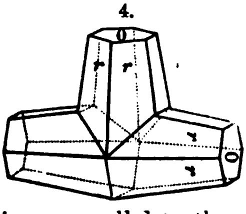
It has already been mentioned that when the twinning plane is $\frac{3}{2}\text{-}\breve{\frac{3}{2}}$ the vertical axes cut each other at an angle of about 60°. It would be expected from this fact that compound crystals of three individuals would be found, the entire circumference being thus divisible by six, and this has been the case. Figure 2 represents one of a considerable number of crystals of this description in which three interpenetrating individual crystals cut each other respectively at angles of 60° and 120°, and, being symmetrically developed, form thus a six-rayed star. Still another form is shown in figure 3; it is interesting as being a combination of two methods of twinning in the same compound crystal which has been rarely observed in any species. The vertical axis of two of the single crystals are at right angles to each other, and that of the third cuts each of the other two at an angle of 60°. This latter fact explains the occurrence of this form.

The crystals figured were from the cabinet of Professor Brush.

2. On a twin of Pyrrhotite.

The annexed figure (fig. 4) represents a remarkable crystal of pyrrhotite, which I have been enabled to examine through the kindness of Dr. Harrington of Montreal.

4.



The crystal itself is somewhat more than three times the size of the cut, and is almost as symmetrically formed. The pyramidal planes (r) are uniformly deeply striated in a horizontal direction, parallel to the basal section; the faces are thus made quite uneven. Furthermore these same planes show a considerable number of minute longitudinal depressions, or etchings, parallel to the vertical axis. This is a prominent feature of all the pyramidal planes alike, thus confirming the accepted hexagonal nature of the species. The transverse crystal, as seen in the figure, is quite irregular, being made up of a group or bundle, of small crystals in parallel position; this is especially true of one of the extremities. These small crystals are some of them free from the striations alluded to and allow of exact measurement. The angle for $r \wedge r$ (basal) thus obtained is 163° ($O \wedge r = 98°30'$); this corresponds to the form $\frac{2}{3}$, which requires 162° 40′ ($O \wedge \frac{2}{3} = 98° 20'$). The twinning plane

the pyramid 1, by which the vertical axes of the two individuals are brought nearly at right angles to each other, since $O \wedge 1 = 135° \ 8'$. This combination of three individual crystals is analogous to the penetration-twins of staurolite, described above.

Dr. Harrington has kindly furnished some notes upon the occurrence and chemical composition of this pyrrhotite, which he allows me to append here.

On the composition and mode of occurrence of the pyrrhotite from Elizabethtown, Ontario; by B. J. Harrington, Ph.D.

The deposit from which the crystal of pyrrhotite was obtained is economically important as being the source from which considerable quantities of pyrite have been derived for the manufacture of sulphuric acid. It occurs on the nineteenth lot of the second concession of Elizabethtown, Ontario, in rocks belonging to the Laurentian system, but its true character has not yet been ascertained. To the mineralogist it is especially interesting on account of the association of minerals which it affords. The minerals number a dozen, and probably more, species, being pyrite, pyrrhotite, magnetite, quartz, talc, labradorite? phlogopite? a compact black mineral probably allied to hisingerite, calcite, siderite, apatite and cacoxenite.

Of these the pyrite and calcite occur in greatest abundance. The former is generally massive, but is sometimes well crystallized—the most common form being a combination of the cube and octahedron. Perfect octahedrons with the axes more than two inches in length have been obtained, and mammillary groupings of cubical crystals with rounded faces occasionally occur. According to the determinations of Hunt and Macfarlane (Geol. of Can., 1863, p. 506, and Can. Nat., 1st Ser., vol. vii, p. 194) the pyrite contains about half a per cent of oxide of cobalt.

Calcite forms the principal gangue in which the other minerals are embedded. It is mostly massive, but is also found on the walls of cavities in the form of obtuse rhombohedral crystals, often curiously modified. It ranges from opaque to transparent, and varies much in color, being white, gray, fawn-colored and sometimes red. The compact black mineral alluded to above also frequently forms the gangue of the pyrites and with it is occasionally associated a triclinic feldspar (probably labradorite) showing a beautiful play of colors. Magnetite is rather common and sometimes occurs in the form of small irregular grains scattered through the calcite. The mineral which I take to be cacoxenite—the occurrence of which in

Canada has not before been noted—is found in beautiful little yellow tufts on the walls of cavities in the calcite, the tufts being often so close together as to form a velvety coating. It is generally associated with pyrite.

Quartz, mica, apatite, talc and siderite were noticed, but they did not form important constituents of the deposit. Pyrrhotite was common in portions of the deposit worked several years ago, but has become less so as the mining has advanced. It is sometimes massive, but more frequently well crystallized. In general it is embedded in calcite, but it has also been found in steatite. The following is an analysis of a crystal:

Iron,	60·560
Copper,	·145
Manganese,	·060
Nickel,	·112
Cobalt,	·111
Sulphur,	39·020
Silica,	·036
	100·044

Hardness between 3½ and 4. Specific gravity 4·622. Readily attracted by the magnet and possessing polarity; the opposite poles seem to be situated not at the extremities of the crystals but along the sides.

A few months ago a crystal of the pyrrhotite was sent to Professor J. Lawrence Smith, who was anxious to compare its composition with that of troilite. The results of his analysis sent to me by him are as follows:

Iron,	59·88
Sulphur,	39·24
Silica (gangue rock),	1·01
	100·13
Specific gravity,	4·642

ART. L.—*Researches on the Solid Carbon Compounds in Meteorites;* by J. LAWRENCE SMITH, Louisville, Ky.

IN the study of Meteorites, it is well known that, of all the simple and compound substances met with in these bodies, the carbon has received the least study and investigation. This has arisen principally from the limited amount of material at the command of the chemist,—a fact to be regretted, since if any one element more than another demands attention, and excites

wonder at the part it plays, either as an element or in its endless combinations with other substances, that element is carbon.

In its elementary condition we see it in crystals of exceeding hardness and brilliancy in the diamond, and also in irregular, nearly opaque masses that are not to be confounded with the diamond. Again, we have carbon in a soft, black, unctuous state, either in lustrous flaky crystals, or in fine-grained masses. It also occurs in the harsh and gritty form of coke, sometimes changed to an unctuous body approaching graphite in aspect, yet different physically as well as in some of its chemical relations. Deposits of anthracite furnish carbon in yet another form. Besides these, the results of decomposition of what are known as organic compounds give quite a list of different forms of carbon, made either by the incomplete combustion of hydrocarbons, or by passing through red-hot tubes the vapors of hydrocarbons, chloride of carbon, sulphide of carbon, etc., or by the decompositions of such substances as carbonic acid, carbides of boron, of iron, of manganese, etc.

These various forms of carbon have certain chemical differences, more or less marked, which differences have attracted the attention of chemists, although no one has studied them with much care or success except M. Berthelot, their investigation being difficult on account of the want of proper methods. M. Berthelot obtained his results by taking advantage of the singularly slow oxidizing action of a mixture of nitric acid and chlorate of potash on carbon, first pointed out by M. B. C. Brodie, in 1860,* in experiments on graphite, by which he produced for the first time what is known as graphitic oxide. He operated by this means on very many specimens of carbon, from the diamond to lamp-black, embracing a large variety of artificially prepared carbons, and discovered certainly six or eight more or less distinct chemical characteristics of these different carbons.† The physical differences of some of them are well known; among these differences none is more remarkable than that of their specific heats. Other bodies known as elements, as silicon and boron, oxygen, etc., take upon themselves different conditions called allotropic conditions,‡—a term applied to the isomeric conditions of simple bodies; but carbon differs from these, not only in exhibiting a most wonderful variety of allotropic conditions, but also in the phenomena coming under the head of isomerism, polymerism, and metamerism; so much

* Annalen der Chemie und Pharm., April, p. 6.

† The full detail of his researches is to be found in the Annales de Chimie et de Physique, IV, xix, 392, 1870 and xxx, 419, 1873.

‡ Notwithstanding the recent experiments of M. Weber, showing that under certain conditions, carbon, silicon, and boron are not exceptions to the law of Dulong and Petit, they still occupy a singular position in regard to specific heat.

so, that we are disposed to take this body away from the rank of a mere element, and call it a protean body that gives rise to substances of endless form and variety by combining with a very limited number of elements.

Additional interest attaches to carbon from the fact of its being regarded as belonging preëminently to the organic kingdom. In fact, some of the best observers and investigators assume that there is no such thing as mineral carbon among the rocks of our globe, and that wherever found, whether as diamond, graphite, or coal, it is a product derived from organic matter, in which it had first performed its part in the economy of nature.

A still more exciting interest has been felt in carbon since the new department of celestial chemistry has received the attention of scientists. And here we are not left for our knowledge of celestial carbon to the attenuated form of it which can be detected only by astronomical instruments; for masses of matter from other spheres reach our globe from time to time, bringing with them specimens of solid carbon for our investigation, and, at the same time, perplexing our minds with questions as to its mineral or organic origin, and as to the existence or not of life on other planets, and in other systems of planets.

Like the footprints of former life on the rock strata of our globe, these indications in what we call meteorites, however slight they may be, are not to be disregarded. While I do not wish to arrogate to myself any undue merit in the study of this subject, I must say that I believe that my methods published in 1855* set forth more prominently than it had been done before, the proper method of research for arriving at correct conclusions. It is clear that to attain positive results, the astronomer, physicist, mineralogist, and chemist must not run counter to one another in the use of the facts severally studied by them; and in all that I have done in this direction, it has been my effort to keep this in view.

In the present memoir, it is my object to develope new facts, and consider some points in connection with the carbon of meteorites.

1. *The Carbonaceous Meteorites.*

Certain well known meteorites, from among those whose fall has been observed, have been called, from their aspect, and from their containing a small amount of carbon, *carbonaceous* meteorites, although the small amount of carbon contained in them is not sufficient to account for their color. Perhaps the term *melanotic* meteorite would be a more appropriate one, to distinguish them from the stony and iron meteorites. There

* This Journal, II, xix, 153, 322.

are but four of them yet known, viz: that which fell at Alais in 1806, that at Kold-Bokeveldt in 1838, that at Kaba in 1857, and that at Orgueil in 1864. They contain, respectively, about 3, 2, 0·6, and 6 per cent of carbonaceous matter.

I would here remark that the Alais, Kold-Bokeveldt, and Orgueil are more closely allied to each other than to the Kaba meteorite. The predominating mineral constituents are about as follows:

	Alais, by Berz.	K-Bokt., by Harris.	Kaba, by Wöhler.	Orgueil, by Pisani.
Silica	31·22	30·80	34·24	26·08
Magnesia	22·21	22·20	22·39	17·00
Iron protoxide	29·03	29·94	26·20	29·60

If we now contrast these mineral constituents with those predominating in well-known meteoric stones, a most striking fact presents itself—one not commonly realized by those engaged in the study of these bodies. It is seen on comparing the above with the following tables:

	Chassigny.	Chateau Renard.	Harrison City.	Concord.	Danville.	Searsmont.
Silica	35·30	38·13	47·30	47·30	50·08	40·61
Magnesia	31·76	17·67	24·53	24·53	20·14	36·34
Iron protoxide	26·70	29·44	28·03	28·03	19·85	19·21

From these tabular statements, it will be seen that, deducting the small amount of carbon contained in the black meteorites, the mass of mineral matter constituting them is about the same, and corresponds thus with the so-called common type of meteoric stones; and hence the mineral matter to which these constituents belong must be the same in the two classes of meteorites, viz: olivines and pyroxenes, differing only in the more or less compact form of these minerals.

In the writings of some of the most astute observers of these bodies, we find little stress laid on these facts. Thus, M. Meunier, in a paper on the origin of meteorites, published in the Cosmos of December, 1869, expresses his amazement that I should speak of the circumscribed uniformity of the composition of meteorites as evidence of a circumscribed cosmical origin of these bodies, both with reference to the sphere or spheres whence they come, as well as their rock structure. He takes so opposite a view as to say (p. 9), "So far from the meteorites showing such a resemblance, we can establish between meteoric iron, olivine meteorites, aluminous meteorites, and carbonaceous meteorites, differences as great as between the most different terrestrial rocks." An assertion which would include all the ranges of rocks and sedimentary deposits from the basalt and granite to the cretaceous and tertiary deposits.

Let any one look at the above table, and say whether or not

he sees so vast a difference in the mineral constituents of the different meteorites there enumerated; and yet they represent the two extremes of these bodies so far as their external properties are concerned. It is well known that three or four minerals represent the great mass of the constituents of every meteorite in various proportions, viz: nickeliferous iron, olivine, pyroxene, and anorthite, especially the first three; and the purely iron meteorites must be recognized as magnified masses of the metallic particles to be found in every stony meteorite, not excepting even the carbonaceous meteorites.*

My object, however, in this paper is not to discuss at length the general internal resemblances of these bodies, as I may have occasion to do it more fully at another time. I wish simply to note, that black and pulverulent as are the carbonaceous meteorites, they are not removed by their mineral constituents from the so-called common meteorites. I now pass on to show that even in their carbonaceous constituent they are strongly linked even to the iron meteorites.

2. *Graphite carbon in the Iron Meteorites.*—Ever since the internal structure of this class of meteorites has been examined by sections through the center of these compact metallic masses, nodular concretions have been noted in their interior, the most common of which consist of *troilite*, a protosulphide of iron, and filling ovoidal cavities. Sometimes these troilite concretions have a thin coating of a lighter colored mineral known as *schreibersite;* and this last is also found alone in concretionary masses which are usually angular or lamellar.

Less frequent concretions than either of the above, and even more remarkable, consist of carbon of the character of graphite: these, like the troilite, usually fill irregular ovoidal cavities, and are more or less contaminated with the latter mineral.

The most important of the meteoric irons containing these nodules, that have come under my immediate observation, are the Toluca, the Cranbourne, the DeKalb, and the Sevier: the last two have received my special study, the latter furnishing much the larger part of the material in my hands.

Character of the graphite nodules.— These concretions differ more or less in appearance, while their general character is the same. In this communication I call special attention to a large nodule taken from the very center of the Sevier iron, the largest that has come under my observation, and perhaps the largest known. It was detached from the iron entire and perfect in every respect. Its greatest length is 60 mm.; its dimensions in

* At present, the Orgueil and Rhoda meteorites are the only two in which no positive evidence of the presence of nickeliferous iron has been traced; in the Orgueil, however, we find nearly three per cent of oxides, nickel and cobalt, and the Rhoda has not been very critically examined.

the other direction vary from 20 to 35 mm. The weight before it was cut was 92 grams. Its form is that of an irregular dumb-bell, flattened on one side, and slightly nodular on the surface. Its color is plumbago-black, except at small places on the surface, where there is a little bronze-colored troilite. Its texture is remarkably close and compact, and it is cut readily by the saw except when the tool encounters particles of enclosed troilite. Its structure and powder is not unlike that of the close-textured graphite of Borrowdale in Cumberland, England, and quite unlike the scaly graphite such as that from Ceylon, or that found in certain cast irons.

Examined from the circumference to the center this nodule presents the following appearances: About one-fifth of the circumference of the section is made up of troilite with a thickness of one millimeter. The remainder of the section has all the aspect of graphite, except in a few spots. In the nodule there is a small mass of troilite not unlike in form the entire nodule; it is 10 mm. long by about 5 mm. wide; it is not continuous from its circumference to its center, but the center portion is cut off completely from the exterior portion by a thin belt of graphite one-half to three-quarters of a millimeter in thickness. Again on other parts of the surface small particles of troilite are to be seen.

The specific gravity of this graphite is 2·26 mm., as determined on a piece in which no troilite was visible to the eye, and after it was immersed in water and placed under the receiver of an air pump to abstract the air from its pores.

Chemical character of the graphitic nodule.—When pulverized and heated in a short glass tube from 100° to 150° C., water is given off which is doubtless water absorbed from the air by the graphite. If heated a little higher and then brought close to the nose, a slight empyreumatic odor is apparent; if heated still higher, there is a slight odor of sulphuretted hydrogen. If heated in the open air the carbon is burnt with difficulty, showing its true graphitic nature.

Treatment of the graphite by ether.—Very pure and concentrated ether was added to two grams of material in powder and rubbed up in a porcelain mortar; then poured into a small beaker; a little more ether was added and the two allowed to remain together for 12 or 18 hours, the vessel being covered to prevent evaporation. The ether was then filtered off from the graphite which was finally washed with a little ether. The ether was allowed to evaporate slowly in the uncovered beaker placed where the temperature was about 33° C. After the ether had evaporated, long colorless acicular crystals covered the sides of the vessel, and some shorter ones were in the bottom. There were also some rhomboidal crystals and rounded particles. The

solid residue exhaled a peculiar odor of an aromatic character, somewhat alliaceous. The quantity of these crystals was small, not exceeding 15 milligrams from two grams of the graphite. Heated on a piece of platinum foil they fuse at about 120° C. Heated in a small tube closed at one end, they first melt and then volatilize, condensing in yellow drops that soon solidify leaving a carbonaceous residue. They are not soluble in alcohol, but very soluble in sulphide of carbon. Fuming nitric acid oxidizes the material, and gives, as one of the products, sulphuric acid. The quantity was too small to admit an ultimate analysis, but it was very evident that sulphur was the predominating constituent, the remainder being carbon and hydrogen. These three elements may be combined, forming a peculiar sulph-hydrocarbon, which in a previous note I called *celestialite*, or it may be sulphur containing a minute quantity of a hydrocarbon that gives the peculiar odor and determines the somewhat singular form of crystallization of the sulphur; for these acicular crystals may be only elongated rhombohedrons.

Be the compound what it may, it is a matter of chemical and astronomical interest that a solid graphite nodule thus encased in iron should contain a sulph-hydrocarbon, or free sulphur and a hydrocarbon.

The graphite powder, after treatment with ether, was then treated with bi-sulphide of carbon (which was re distilled just before use) and after standing two or three hours was thrown on a filter; the filtrate was evaporated to dryness, and the residue was a yellow solid; in this instance, as in the last, the quantity was small. This, when heated in the open air on platinum foil to a red dull heat, first melts at about the temperature that sulphur melts, and finally the sulphur is burnt off, leaving a carbonaceous residue. When heated in a tube, it sublimes, leaving a black residue.

To all appearances this is the same substance, or mixture of substances, that was extracted by the ether, the ether not having exhausted the graphite in the first treatment.

The graphite nodules of the DeKalb and of the Cranbourne irons, on treatment with ether and sulphide of carbon, gave similar results. In the case of the Cranbourne graphite I had less than one hundred milligrams of the material to operate with, and I hardly hoped to obtain satisfactory results, but I did succeed, however, in obtaining such without the acicular crystals, for the whole residue was less than one milligram; but I had enough to recognize the peculiar odor, and also the minute quantity that could be scraped off the vessel in which the evaporation took place furnished the marked reaction by heat of volatilization in part and condensation of the same

with a carbon residue. The Cranborne graphite requires more trituration with the ether than that from the Sevier meteorite as it is more flaky on being rubbed up.

Further remarks about this peculiar substance will be made a little farther on, when I come to speak of the same compound as obtained from the black or carbonaceous meteorites.

[To be continued.]

ART. LI.—*Contributions from the Sheffield Laboratory of Yale College.* No. XXXVIII.—*On the Oxidation product of Glycogen with Bromine, Silver Oxide and Water;* by R. H. CHITTENDEN, Ph.B., Assistant in Physiological Chemistry.

WHILE submitting an aqueous solution of glycogen to the action of bromine in an open vessel with the aid of heat, it was observed that the strong opacity of the fluid gradually disappeared, and that, after the removal of the free bromine by partial evaporation, a perfectly clear fluid remained which contained considerable combined bromine.

This reaction, indicating union between the glycogen and bromine, pointed to the possibility of the formation of an acid from the glycogen by oxidation, in a manner analogous to the formation of "dextronsäure" from dextrin, and "lactonsäure" from lactose, as described by Habermann,* Barth and Hlasiwetz.† The following experiments were undertaken to form, if possible, a corresponding acid from glycogen. The glycogen employed was prepared from the muscular tissue of *Pecten irradians*,‡ and was as pure as could be obtained. The process of oxidation was as follows: fifty grams of glycogen dried at 100° C., were dissolved in 300 c.c. of distilled water, and this solution transferred to a champagne flask fitted with a caoutchouc stopper, in which was a small stout glass tube drawn out to a point.§ Forty grams of bromine were then added and the stopper wired in. The flask was then heated in a water bath until the red vapors of bromine had entirely disappeared, which required about two hours' boiling. A heavy light yellow or white precipitate formed at first, which completely disappeared by the time the bromine had all been taken up. At the end of this first treatment the fluid was perfectly clear and of a pale yellow color. After cooling, the gases were allowed to escape, by breaking the end of the tube in the cork, and, being collected, were found to consist mainly of carbonic acid and bromoform. The stopper was then removed and 40 grams more bromine

* Annalen der Ch. u. Pharm., clxii, 297. † Ibid., cxxii, 96.
‡ This Journal, III, vol. x, p. 26. § Annalen der Ch. u. Pharm., clix, 315.

added. The flask was then closed and heated as before until the bromine had all been taken up, after which, on cooling, the gases were liberated and 40 grams more bromine added, and the flask treated as before. After this, 10 grams of bromine were added three times, so that 150 grams of bromine were employed in the oxidation of 50 grams of dried glycogen.

The fluid was then transferred to an evaporating dish and heated on a water-bath until somewhat concentrated. When cool the fluid was diluted with an equal volume of water, then mixed with freshly precipitated and thoroughly washed silver oxide until all bromine was removed from the fluid. After the silver bromide had completely settled, the fluid was filtered off and the silver contained in it precipitated by hydrogen sulphide. The silver sulphide was removed by filtration, and the filtrate upon partial evaporation left a yellowish-red fluid with strong acid taste and reaction. This was an impure solution of an acid which decomposed carbonates with avidity. In this manner 150 grams of dried glycogen were oxidized, in parts of 50, giving in all sufficient acid for the following experiments. Two methods of purification were employed. The first consisted in treating this impure solution of the acid with chemically pure animal charcoal, and precipitating the filtrate with an excess of alcohol, to remove inorganic salts derived from the glycogen, which the latter always contains in small quantity. This alcoholic filtrate is evaporated on the water-bath, when a moderately pure solution of the acid results.

The second and better method, however, is to treat the impure acid with pure calcium carbonate, on the water-bath, when a soluble calcium salt is obtained which is filtered off, and, after concentration, crystallizes out on standing several days. After washing the crystals with a little cold water, they are dissolved in a large quantity of hot water, and precipitated while still hot by basic lead acetate. This precipitate of a lead salt of the acid is washed with hot water, then emulsionized with water and decomposed by hydrogen sulphide. The lead sulphide is removed by filtration, the fluid evaporated, and then mixed with an excess of dilute alcohol. The precipitate, if any forms, is filtered off, and the filtrate on evaporation leaves the pure acid as a thick colorless syrup, which, after standing several months, shows as yet no signs of crystallization. A solution of the acid in water has an acid reaction on litmus; a strong acid taste; is not precipitated by alcohol, and dissolves freshly precipitated hydrated copper oxide to an azure-blue fluid, which remains blue when heated, but after long boiling shows strong reducing action.

Calcium Salt.—On treating an aqueous solution of the acid with calcium carbonate, on the water-bath, a violent evolution of carbonic acid takes place, and, after some time, a soluble calcium

salt can be filtered off from the excess of calcium carbonate. If the solution is at all colored it can be purified by animal charcoal. When suitably concentrated, this solution on standing several days, changes into a mass of irregular white globules, which are aggregations of fine microscopic needles.

The air-dried salt, when heated to 100° C. loses only hygroscopic water, and, when heated above 100° C. turns brown, which would indicate decomposition. The salt after crystallization is difficultly soluble in cold water; readily soluble in hot water, and is precipitated from its aqueous solution by alcohol.

The analysis of the salt gave the formula: $C_6H_{11}Ca'O_7$.

I. 0·2097 grams of the salt dried at 100° C. gave ·2552 grams CO_2 and ·1015 grams H_2O.

II. 0·317 grams of the dried salt gave ·3851 grams CO_2 and ·1508 grams H_2O.

III. 0·3305 grams of the dried salt gave ·0429 grams CaO.

IV. 0·272 grams of the dried salt gave ·036 grams CaO.

	Calculated.	Found.			
		1.	2.	3.	4.
C_6	33·49	33·18	33·12	....	....
H_{11}	5·12	5·37	5·28	....	....
Ca'*	9·35	....	....	9·27	9·45
O_7	52·05	....	....	....	....

Barium Salt.—On treating a portion of the acid on the water-bath with barium carbonate, the latter salt is decomposed, and a soluble barium salt of the acid results. The salt thus formed does not crystallize readily from this solution. Alcohol is then added in excess to the fluid, when a heavy white precipitate forms, flocculent at first, but soon becoming gummy. This precipitate is washed with alcohol, and after drying has the appearance of a hard yellow gum. The gum-like mass is dissolved in water, filtered through animal charcoal, and evaporated to a small bulk, when, after standing a week, the fluid is converted into a mass of quite large, white, glassy prisms, which contain water of crystallization.

The analysis of the salt dried at 100° C. gave the formula: $C_6H_{11}Ba'O_7$. The air-dried salt gave the formula: $C_6H_{11}Ba'O_7+1\frac{1}{2}H_2O$.

I. 0·347 grams of the salt dried at 100° C. gave ·3488 grams CO_2 and ·1402 grams H_2O.

II. 0·2778 grams of the dried salt gave ·2793 grams CO_2 and ·1102 grams H_2O.

III. 0·498 grams of the dried salt gave ·1872 grams $BaCO_3$.

IV. 0·3117 grams of dried salt gave ·1175 grams $BaCO_3$.

V. 1·2257 grams of the air-dried salt gave by drying at 100° C. ·11542 grams H_2O.

* Ca'=20.

	Calculated.	Found. 1.	2.	3.	4.	5.
C_6	27·32	27·41	27·41	----	----	----
H_{11}	4·17	4·48	4·40	----	----	----
Ba'*	25·99	----	----	26·14	26·21	----
O_7	42·54	----	----	----	----	----
$1\frac{1}{2}H_2O$	9·64	----	----	----	----	9·41

The crystals of this salt are very readily soluble in hot and cold water, but insoluble in alcohol.

The air-dried crystals when placed over concentrated sulphuric acid lose 6·42 per cent of water. The calculated amount for one molecule of water is 6·74 per cent. On drying the crystals at 100° C. the remaining one-half molecule is driven off. Heated at 120° C. the crystals turn brown and swell up.

Cadmium Salt.—On treating an aqueous solution of the acid with cadmium carbonate, on the water-bath, a soluble cadmium salt is obtained which does not crystallize. The salt is precipitated from its solution by three or four volumes of alcohol, then redissolved in water, filtered through animal charcoal, and reprecipitated by alcohol. It is thrown down from its solution as a flocculent precipitate which soon becomes gummy, and when hard yields on trituration a perfectly white powder.

The analysis of the salt dried at 100° C. gave the formula: $C_6H_{11}Cd'O_7$.

I. 0·3924 grams of the salt dried at 100° C. gave ·4105 grams CO_2 and ·1618 grams H_2O.
II. 0·3544 grams of the dried salt gave ·3702 grams CO_2 and ·1412 grams H_2O.
III. 0·344 grams of the dried salt gave ·0989 grams CdS.
IV. 0·3568 grams of the dried salt gave ·1023 grams CdS.

	Calculated.	Found. 1.	2.	3.	4.
C_6	28·68	28·52	28·48	----	----
H_{11}	4·38	4·58	4·42	----	----
Cd'†	22·31	----	----	22·36	22·29
O_7	44·70	----	----	----	----

Cobalt Salt.—On heating an aqueous solution of the acid with cobaltic carbonate, on the water-bath, a cherry-red solution of a cobalt salt of the acid, is obtained, which does not crystallize readily from the aqueous solution. On the addition of alcohol to a concentrated or only moderately dilute solution of this salt, a heavy pink colored precipitate forms which soon becomes gummy.

This precipitate, after being washed with alcohol and dried at 100° C. gave by analysis the formula: $C_6H_{11}Co'O_7$.

* Ba'=68·5. † Cd'=56.

I. 0·279 grams of the salt dried at 100° C. gave ·325 grams CO_2 and ·1213 grams H_2O.
II. 0·283 grams of the dried salt gave ·3325 grams Co_2 and ·1200 grams H_2O.
III. 0·2005 grams of the dried salt gave ·0268 grams Co.

	Calculated.	Found. 1.	2.	3.
C_6	32·07	31·76	32·04	....
H_{11}	4·89	4·83	4·71	....
Co′*	13·14	....	....	13·36
O_7	49·89	....	....	....

From a very dilute solution in water, the cobalt salt is precipitated by alcohol in the form of pink flocks. On allowing this precipitate to stand several weeks in the alcoholic fluid, it will be found to have changed its form, and under the microscope, will be seen to consist of fine needle-shaped crystals. These crystals dried at 100° C. gave by analysis the formula: $C_6H_{11}CoO_7+H_2O$.

I. 0·219 grams of the salt dried at 100° C. gave ·2372 grams CO_2 and ·108 grams H_2O.
II. 0·2992 grams of the dried salt gave ·3225 grams CO_2 and ·1484 grams H_2O.
III. 0·2052 grams of the dried salt gave ·0254 grams Co.

	Calculated.	Found. 1.	2.	3.
C_6	29·69	29·53	29·40	....
H_{13}	5·36	5·47	5·51	....
Co′*	12·16	....	....	12·37
O_8	52·78	....	....	...

Manganese Salt—A solution of the acid treated, as in the preceding methods, with manganic carbonate, forms a soluble manganese salt which separates from the suitably concentrated fluid in masses of fine microscopic feather-like crystals. These crystals upon close examination are seen to be made up of radiating needles. When agitated in water they have a brilliant silky luster. They are slightly yellow, soluble in water, but insoluble in alcohol. The salt dried at 100° C. gave by analysis the formula: $C_6H_{11}MnO_7$.

I. 0·305 grams of the salt dried at 100° C. gave ·362 grams Co_2 and ·142 grams H_2O.
II. 0·353 grams of the dried salt gave ·062 grams Mn_3O_4.

	Calculated.	Found. 1.	2.
C_6	32·35	32·36	....
H_{11}	4·94	5·17	....
Mn†	12·35	....	12·65
O_7	50·33	....	....

* Co′=29·5. † Mn′=27·5.

Lead Salt.—On treating an aqueous solution of the calcium salt with basic lead acetate, best with the application of heat, a heavy white gelatinous precipitate is obtained, which after washing with hot water and drying at 100° C., yielded by analysis the formula: $C_6H_8Pb_2O_7$.

I. 0·280 grams of the salt dried at 100° C. gave ·115 grams CO_2 and ·0358 grams H_2O.
II. 0·3855 grams of the dried salt gave ·1645 grams CO_2 and ·0505 grams H_2O.
III. 0·436 grams of the dried salt gave ·3212 grams PbO.
IV. 0·1522 grams of the dried salt gave ·1122 grams PbO.

	Calculated.	Found. 1.	2.	3.	4.
C_6	11·88	11·20	11·63	....	....
H_8	1·32	1·42	1·45	....	....
Pb''_2	68·31	....	....	68·38	68·43
O_7	18·49	....	....	....	....

On adding a solution of neutral lead acetate to an aqueous solution of the acid, a white flocculent precipitate is obtained. A similar precipitate is obtained with basic lead acetate. These precipitates, after washing with water and drying at 100° C., gave by analysis the following results:

	Precipitate produced by neutral lead acetate.		Precipitate produced by basic lead acetate.
C	11·60	C	11·42
H	1·42	H	1·55
Pb	68·19	Pb	68·66
O	18·79	O	18·37

A silver salt was also obtained as a flocculent precipitate. This was not analyzed.

By a backward glance we see that in all the salts obtained, with the exception of the lead salt, the acid acts as a monobasic acid. In the case of the lead salt, however, four atoms of hydrogen are replaced by two atoms of the metal. Hlasiwetz in an article upon the basicity of "lactonsäure" and "gluconsäure,"* in which he shows that these acids are not only monobasic but also dibasic, gives a method whereby he obtained a dibasic barium salt from a monobasic calcium salt. On treating an aqueous solution of the monobasic calcium salt of this acid in the same manner, viz: with baryta water, and heating to boiling, a white flocculent precipitate is obtained, which after washing with hot water and drying at 100° C. gave by analysis the formula: $C_6H_{10}Ba''O_7$.

I. 0·282 grams of the salt dried at 100° C. gave ·2192 grams CO_2 and ·0905 grams H_2O.
II. 0·1585 grams of the dried salt gave ·1235 grams CO_2 and ·0505 grams H_2O.
III. 0·3255 grams of the dried salt gave ·192 grams $BaCO_3$.

* Annalen der Ch. u. Pharm., clviii, 253.

	Calculated.	Found. 1.	2.	3.
C_6	21·75	21·19	21·24	....
H_{10}	3·02	3·56	3·54	....
Ba''	41·38	....	....	41·01
O_7	33·83	....	....	....

The formation of this salt, together with the lead salt, shows that from this acid both monobasic and dibasic salts can be formed.

The formula of the acid is $C_6H_{12}O_7$ and in the oxidation of the glycogen we can assume that the following reactions take place: $C_6H_{10}O_5+H_2O+2Br=C_6H_{12}O_6Br_2$. Adding silver oxide to the bromine compound we have:

$$C_6H_{12}O_6Br_2+Ag_2O=C_6H_{12}O_7+2AgBr.$$

From analogy, it would seem proper to apply to this acid the name glycogen acid.

The preceding analyses and reactions show conclusively that by the action of bromine, water and silver oxide on glycogen, an acid is formed which bears the same relation to glycogen as "dextronsäure" to dextrin. On comparing this acid with the descriptions of "gluconsäure"* and "dextronsäure,"† we see that the glycogen acid differs from the two no more than the two differ from each other. There is also the same relationship existing between glycogen acid and the acid or acids obtained by the oxidation of amylum and paramylum‡ by Haberman, which latter show but few points of difference from "gluconsäure" and "dextronsäure."

February 26th, 1876.

ART. LII.—*On the existence or not of Horns in the Dinocerata;* by RICHARD OWEN. (Letter to the Editors of this Journal, dated London, Feb. 24, 1876.)

GENTLEMEN: Among the new forms of extinct Eocene mammals of America, for which science is indebted to Professor O. C. Marsh, those which he refers to "the new order *Dinocerata*" are the most singular.

The study of their characters, especially as described and illustrated in your Journal,§ has led me to submit a few remarks on the subject of "horns." These weapons in mammals, if formed or supported by bone, are either "autogenous" or "exogenous," either "epiphyses" or "apophyses;" terms which signify, in a word, either, that the horn is ossified from an independent center and

* Annalen der Ch. u. Pharm., clv, 120. † Ibid., clxii, 297. ‡ Ibid., clxxii, 11.
§ Vol. xi, February, 1876, p. 163.

afterwards coalesces with a cranial bone, or that it grows, as a process, from a cranial bone.

The giraffe yields an instance of the "autogenous" horn, and its skull, in either the recent or fossil state, shows the basal sutures. In other species the horns or horn-cores are "exogenous;" and such, in the absence of the sutural evidence, are the parts called "horn-cores" in the *Dinocerata.*

But before elevations or processes of cranial bones can be pronounced to be "horn-cores," the evidence of the horns they supported should be forthcoming. Paleontology, it is true, infers the existence of horns supported on bony bases, or "horn-cores," in extinct species in which such horns have perished. *Bos antiquus*, *Bison priscus*, *Sivatherium*, *Bramatherium*, are rightly referred to the "hollow-horned" group, and the two latter may seem more germain to the present question, seeing that the "horn-cores" are in two pairs. Such conclusion is based on the presence of foramina and ramified grooves upon the surface of the "cores," which are known to be the effects of the penetration and pressure of blood-vessels supplying the growth and renovation of the horny sheaths of such bony processes. The same evidence reveals the true nature of the horn-cores, which may be covered with skin instead of horn, such as are the horns of deer, from which when complete the skin is shed.

In the absence of such evidence the paleontologist infers that smooth unfurrowed protuberances or processes of cranial bones were covered, like the rest of the outer surface of the bones developing them, with persistent periosteum and skin, in the existing animal. He refrains from calling them "horn-cores," and from defining the extinct species manifesting them, as "horned," "four-horned," or "six-horned," *Dicerata*, *Tetracerata*, *Hexacerata ;* or, as in the case of the hornless herbivores of the Wyoming Eocene, *Dinocerata :* because such terms imply the possession by those extinct quadrupeds of weapons of which there has not, at present, been given any evidence.

Professor Marsh, indeed, candidly admits in regard to the protuberances which suggested the generic name *Dinoceras*, that they "may possibly have been covered with thick skin and not with true horn."† But we have no evidence of the integument having been thicker, or other on the protuberances than on the cranial bones developing them.

It may be noted that the hornless exceptions in the group of existing herbivorous quadrupeds with true horn-cores and horns, the hornless *Moschidæ*, e. g., are furnished with other weapons of defense, a pair, namely, of long, edged, and sharp-pointed canines descending from the upper jaw.

The hornless *Dinoceras* was similarly armed, and Professor Marsh believes he has evidence of a sexual difference of size in those dental weapons, which would yield another analogy to the existing Musk-deer. But the dental and osteal characters of the

† Loc. cit., p. 164.

pentadactyle *Dinoceras* are consistently "perissodactyle." The truly remarkable peculiarity of its skull is the tendency of the outer wall of the bones to extend into ridges and bosses; and this not only in the cranium proper and upper jaw, but also in the lower jaw. If these bosses were legitimately interpretable as "horn-cores," we must give the animal a pair of horns descending from the under and forepart of the mandible to match the pair ascending from the maxilla. But the singular processes descending and diverging, as a pair, from the mandibular rami, show as marked an absence of any indication of their having been sheathed with horn as do the pairs of protuberances from the nasal, maxillary, and the frontal bones above.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Diplometer.*—M. Landolf has invented an instrument for measuring the diameter of objects without touching them and independently of their movements. A wedge-shaped piece of glass is cut in two along a plane perpendicular to the edge of the wedge, and joined together again after turning one piece 180°. Looking through the line of junction of the prisms, objects will appear double, because the prisms will deviate the rays in opposite directions. When the two images appear just in contact the doubling will be just equal to the diameter of the object. Hence knowing the distance we can compute the diameter, or *vice versa.* The prisms slide over a graduated rod so that the object being placed at one end they are moved until the two images are just in contact, when the distance furnishes a ready means of determining the diameter. In the instrument actually constructed a distance of 42 mms. corresponded to an overlapping of 1 mm. Consequently tenths of a millimeter were readily measured. Evidently motions of the object do not affect the measure since both images move together.—*Comptes Rendus*, lxxxii, 424.

[Numerous applications of this instrument will suggest themselves. In natural history the dimensions of various parts of animals or plants, whether large or small may be found, and in physics objects which cannot be touched, as bubbles, vibrating bodies, &c., may be quickly measured. By setting the prisms as an eye-glass this instrument would form a convenient substitute for a telescope, in measuring distances with a telemeter.] E. C. P.

2. *Specific Heat of Gases.*—M. Wiedemann has published in full his measurements of the specific heat of gases referred to in a recent number of this Journal (cviii, 465). His results are given in the following table in which the first column gives the name of the gas, and the second, third and fourth its specific heat under constant pressure at temperatures of 0°, 100° and 200°. The last

three columns give the corresponding specific heats under constant volume:

Name.	Constant Pressure. 0°	100°	200°	Constant Volume. 0°	100°	200°
Air,	·2389			·2389		
Hydrogen,	3·410			·2359		
Carbonic oxide,	·2426			·2346		
Carbonic acid,	·1952	·2169	·2387	·2985	·3316	·3650
Ethyl,	·3364	·4189	·5015	·3254	·4052	·4851
Nitrous oxide,	·1983	·2212	·2442	·3014	·3362	·3712
Ammonia,	·5009	·5317	·5629	·2952	·3134	·3318

—*Pogg. Ann.*, clvii, 1. E. C. P.

3. *Crooke's Radiometer.*—Mr. G. J. STONEY presents an explanation of the apparent repulsion produced by heat, according to the Kinetic theory of gases. Mr. Crookes has shown that the pressure produced on a blackened surface of two square inches by the light of a standard candle six inches distant would be ·001772 grains or somewhat less than ·01 milligram per square centimeter. Assuming that the pressure of the air in the interior is reduced to ·1 mm. there would still be something like a hundred million of millions of atoms in each cubic millimeter. These atoms will consist in part of oxygen and nitrogen from the air, of mercury and hydrocarbons, and probably in part of platinum, glass and other substances in a gaseous form.

The blackened surface will be heated by the candle more than the glass by an amount which may be assumed at ·1° and the air in contact with it will vary in temperature from that of the disk to that of the enclosing air. Were the air at its ordinary pressure the heated layer would be very thin, and may be estimated at about ·0005 mm., or about the wave-length of green light. With the small pressure here employed, however, the case is quite different, and the thickness of the layer would equal $·0005 \times (7600)^{1·33}$, or over a decimeter. The heated layer therefore extends to the wall of the surrounding vessel, and now a heat engine is formed by the particles of air which strike the disk with a velocity due to a temperature of perhaps 15°, and are repelled from it with a velocity due to its temperature of 15·1°. The resultant pressure on the disk may be readily computed and is found to be ·0115 milligram which agrees closely with ·01, as observed by Mr. Crookes. In other words a difference of temperature of ·1° C. is sufficient to account for the observed pressure.—*Phil. Mag.*, 1, 177.

[The measurement here referred to, is described in *Engineering*, Feb. 18th, and was effected in the following manner: A torsion balance was constructed with a horizontal glass fiber and with a horizontal arm terminating in a cup at one end and in a disk of pith at the other. A small piece of iron weighing a hundredth of a grain was raised by a magnet and dropped into the cup. It was then found that the fiber must be turned through 100021° to bring the arm back to its original position. The light of a candle at a distance of 6 inches was next allowed to fall on the pith, when a torsion of 1775° was required to bring it back. This corres-

ponds to ·001772 grains, or about an eighth of a grain per square foot. From this it would appear that the light of the sun would be equivalent to 32 grains per square foot or 57 tons per square mile. Mr. Crookes further applies this instrument as a photometer and suggests its application to observatories to determine the total amount of sunlight received during the year. The number of revolutions could be counted by attaching a magnet to the radiometer which should act on a magnetic needle moving a counter outside of the glass case. Similarly the power of the instrument might be transmitted through the glass without the usual loss by friction.

Numerous other articles appear on the same subject. Poggendorff and Neesen (Bibl. Univ., ccxvii, 84, and Phil. Mag., l, 251) publish independent series of experiments from which they conclude that the repulsion is due to convection currents. Several articles appear also in 'Nature,' on the radiometer; on p. 391, Mr. Crookes shows that the repulsion is inversely as the square of the distance and compares the effect of rays of various wave lengths. On page 324, Mr. Hutchinson states that a radiometer with mica vanes on metallic supports revolves more rapidly with dark heat than with light, but Mr. Crookes replies that pith should be used as the absorbing substance, since metals give erratic results.] E. C. P.

4. *The Gram Magneto-electric machine.*—M. TRESCA has made a careful measurement of the power required to drive a large and a small gram machine and compared the result with the light generated. A photometer disk was used, of which one portion was illuminated only by the electric light and an adjacent portion only by a carcel burner consuming 40 grams of oil per hour. Much trouble was experienced from the difference in color of the two lights, and the equality was best obtained by interposing two plates of glass, one of light green and the other of light pink. Owing to irregularities in the carbons the light continually underwent irregularities sensible only to the photometer. The light of the larger machine was placed 40 meters from the disk and the burner moved until the square of their distance should be as 1850 : 1, which was about the mean ratio of the two lights. When the two portions of the disk appeared equally bright the observer gave a signal and instantly the power and velocity were observed. The larger machine had a length of 80 cms., width 55 cms., and height 58·5 cms. The average number of turns per minute was 1274, and the work 576 killogrammeters or 7·68 horse-power. The light being 1850 burners, would equal ·415 of a horse-power per 100 burners, or ·31 kgms. per burner.

The smaller machine had a length of 65 cms., breadth of 41 cms., and height of 50·6 cms. It made 872 turns per minute, and gave a light of 302·4 burners. This required 211 kgms., or 2·8 horse power, equivalent to ·92 of a horse power per hundred burners, or ·69 kgms. per burner.

The consumption of oil to produce a light equal to that of the larger machine would be about 71 kgs. per hour or 194 cubic

meters of gas. The cost of the oil would be therefore in Paris about a hundred times that of the electric light, or that of gas fifty times, to produce the same light. The comparison with the smaller machine would be less favorable. The carbons for the larger light had a cross section of 81 mms., and the ordinary consumption was a little over a centimeter in length per hour.—*Comptes Rendus*, lxxxii, 299. E. C. P.

5. *Effect of increase of temperature on the Index of Refraction;* by Professor T. P. Mendenhall. Letter to the editors, dated Columbus, Ohio, April 10, 1876.—Dear Sirs: I have in progress an investigation of the effect of increase of temperature on the index of refraction, which has at this time yielded some results of considerable importance to spectroscopists. In 1858 Messrs. Gladstone and Dale announced as the conclusion of a research upon this question, that in every substance the refractive index diminishes as the temperature increases. I am satisfied that glass at least does not obey this law; that, on the contrary, with it the index increases with the temperature. In my experiments I have used equilateral glass prisms with indices of refraction of about 1·63. The change in the position of the D line has been observed with a parallel wire micrometer. That the effect was not due to a change in the angle of the prism during the process of cooling I satisfied myself—both by measurement of the angle when hot and when cold—and by receiving the image of the slit of the collimator reflected from both faces upon the cross hairs of two telescopes properly adjusted upon the instrument. No appreciable change in angle could be discovered. Numerous experiments agree well in fixing the "index of sensitiveness," but the quantitative results I have not fully worked out. I only wish at present to direct attention to the fact, that, in the use of a train of several glass prisms in a spectroscope, ordinary changes of temperature to which the instrument may be subjected will produce a very noticeable change in the position of the spectrum lines. In my own, of five large prisms, of an angle of 64°, the change in the position of the D line on removing the prisms from an open window, the temperature outside being about 32° F., to the room, at ordinary temperature was as much as 95 divisions of the micrometer screw head. With a smaller number of prisms the change was closely proportioned to that number. I wish to suggest that in this way may be found the cause of many discrepancies which occur in tables of wave-lengths, as furnished by different workers, in such cases as those in which the dispersion spectrum has been made use of, and the wave-length computed by interpolation. A great many such cases occur in Watt's Index of spectra. In an instrument of many prisms the observation of temperature will be a matter of vital importance in fixing the exact position of a line. I propose to pursue the investigation, especially in respect to the observation of lines more or less refrangible than the D, and also as to the effect of change of temperature upon other than glass prisms.

II. Geology and Mineralogy.

1. *Does the actual vegetation of the Globe furnish any general marks by which it could be recognized in all countries if it became fossil?*—This question is asked by Alph. DeCandolle in a brief article in the Archives des Sciences of Geneva for December, 1875. The question is answered in the negative, as was inevitable. For, as the author observes, the species of plants over the globe differ so widely with difference of locality that it would be exceedingly difficult, or rather, impossible, to draw the line between differences in species due to local distributions, and those due to successional relations. The difficulties, moreover, are greatly increased through the fact, well illustrated by Dr. Gray, that the vegetation of the northern hemisphere has widely changed place during even the Quaternary, and also more than once in earlier time. It hence follows, as DeCandolle urges, that any conclusions as to the succession or cotemporaneity of species in Europe could not be expected to be applicable to America or the other continents; and even the deposits of the several natural regions of a continent would not admit of being synchronized without great doubts over the conclusions. This special inference is not new to geologists; for they admit that with the best of evidence they cannot make out, except very uncertainly, the equivalency of the successive rocks of Europe and America.

But while this general proposition is well sustained, other questions are suggested by the author which appear to demand a reference to a wider range of facts than his paper considers.

Professor DeCandolle seems to regard all fossils as equally poor registers of geological age with plants. It is certain that fossil plants are a most unsatisfactory means of determining equivalency. *Marine* plants—in wonderful contrast with marine animals—have varied little through the geological ages; and hence if plants are used at all for chronological purposes we are confined, with hardly an exception, to the *terrestrial* species. But the terrestrial species, while much more diverse than the marine, include only a very limited series of distinct types, and floras have continued the same or similar through very long ages. Besides, *terrestrial* species, whether vegetable or animal, are more confined in their distribution through physical conditions than those of salt-water; and, further, they are far more poorly represented in the rocks than marine species. For these reasons, and because of the great doubts that come from migrations, the geologist makes little use of fossil plants except for the purpose of characterizing in a general way the floras of the grander divisions of geological time. In actual fact, geologists, in their subdivisions or identifications of formations, have relied almost solely on evidence from fossil animals, and especially marine animals; and if fossil plants are mentioned as the characteristics of a period or age, it has been, with rare exceptions, only after the question of the period or age has been decided by means

of other evidence. Evidence from these other sources has its doubts, but it is not of so small value as that from plants. This comparative want of value is well illustrated by the present wide divergence between Paleophytologists and general Paleontologists with regard to the age of the plant-bearing beds of the Rocky Mountains, the Arctic regions, and Europe. An allusion to the uncertainties of Botanical evidence in the Rocky Mountain region may be found on page 149 of this volume.

But Prof. DeCandolle makes the evidence from plants of less value, we think, than is reasonable. He says: No one would dare to assert that during the progress of a given bed of Pennsylvania coal, there did not exist somewhere, perhaps far away, an elevated region less moist, on which Angiosperms were already in existence. The supposition is a forced one. For, in Cretaceous and Tertiary times, Angiosperms were the plants of *moist* lands, their leaves abounding in the coal-formations of those eras; and it is hence natural that they should have abounded in moist places also in the Carboniferous age, if in existence then along with the Acrogens and Gymnosperms.

In the Carboniferous period of North America, the peat-making marshes at times spread from Eastern Pennsylvania to Western Iowa and Arkansas, covering an area of more than 500,000 square miles; and, at the same time, there were dry hills or mountains along the borders of the marshes, in New York, New Jersey, Ohio, Wisconsin, Missouri, Arkansas, through all that long age. The Adirondacks were certainly in existence, and the Green Mountains, and the Highlands of New Jersey, and other ridges or mountains beyond the Mississippi. The area of those Carboniferous marshes with their surroundings was large enough, and varied enough in surface, to have borne a fair representation of the flora of that era of approximately uniform climate; and still the streams from the hills conveyed, so far as yet discovered, no leaves of Angiosperms to the marshes that bordered the hills. The Coal-measures of the Arctic bear similar testimony, whether there by migration or not, and so do those of Europe. Further, Permian, Triassic and Jurassic beds overlie the Coal formation both in America and Europe and have afforded no remains of Angiosperms. It is from facts like these that geologists have been led to infer that the flora of those lands during the Carboniferous age had characteristics distinguishing it very decidedly from that of other ages; and to deem it probable that the precursors of the Angiosperms existed then in a state unlike that of a Cretaceous or modern Angiosperm.

Prof. DeCandolle adds, in the same paragraph, that if fossil Angiospermous plants were found by geologists in any rock "that rock would be at once pronounced of the Cretaceous age," [or of later time]. In reply I only repeat that geologists are very generally convinced that the evidence from fossil plants is not to be trusted, and make the plants of whatever age the fossil *animals* present may indicate. The "Cretaceous" plants of the United States are

the plants of beds which had previously been determined, through the animal fossils, to be Cretaceous; and, if geologists finally conclude that the flora of the Lignitic beds is all Cretaceous, it will be done on the ground of the animal relics, and in spite of what has been regarded as good botanical evidence.

While then there may be doubts over chronological conclusions from fossils of whatever kind, the geologist who surveys the whole field finds those doubts less weighty than they would naturally appear to one who looked at the subject from the botanical side alone. J. D. D.

2. *Report of the Geological Survey of Ohio.* Volume II. *Geology and Palæontology.*—Part. II, *Palæontology*, (or, as stated on the cover, Palæontology, Vol. II.) 436 pp. roy. 8vo, with over sixty plates. Columbus, Ohio, 1875.—This large volume contains, after a preface, by Dr. J. S. Newberry, the head of the survey, descriptions of Fossil Fishes, by Dr. Newberry, pp. 1–64; of Silurian Fossils, and of Crinoids from the Waverly group, by J. Hall and R. P. Whitfield, pp. 65–179; of Silurian and Devonian Corals, by H. A. Nicholson, pp. 181–268; of Invertebrate Carboniferous Fossils, by F. B. Meek, pp. 269–347; of Carboniferous Amphibians, by E. D. Cope, pp. 349–411; of Lower Carboniferous fossil plants, by E. B. Andrews, pp. 413–426. The paleontological work was thus in able hands, and covers a large number of species in each of its departments. The portions giving the most novel results are those of the Fishes and Amphibians, and the Lower Carboniferous plants.

Dr. Newberry describes the genus *Dinichthys* from new and magnificent specimens—including broad plates of the venter and back, fifteen inches to two feet in length, a mandible twenty-two inches long, a cranium almost complete, and other bones—and shows that it was closely related to *Coccosteus*. The large ventral pieces were five in number. The anterior end of the mandible was turned up so as to form a strong acute prominent tooth, which had a produced dentate margin in one species. The dentition resembles that of the living *Lepidosiren*; and Dr. Newberry refers the genus (along with *Coccosteus*, *Heterostius*, *Asterolepis*, *Pterichthys*, etc.), to the Lepidosiren group, or the Dipnoa, and agrees with Dr. Günther in placing the Dipnoans and Placoderms with the Ganoids. A species of Coccosteus, *C. occidentalis* Newb., is described from Ohio. Dr. Newberry describes "Conodonts" from the Waverly group, which he is inclined to refer to the Marsipobranchs. He also gives new species of *Cladodus*, *Polyrhizodus*, *Orodus*, *Ctenacanthus*, *Lystracanthus*, *Platyodus*, *Rhynchodus*, *Ctenodus*, *Dipterus*, and introduces the new genus of Ganoids, *Heliodus*, for species near those of *Dipterus*. Dr. Newberry, after remarking that the occurrence together of the spines *Ctenacanthus furcicarinatus*, the teeth *Orodus variabilis*, and certain dermal tubercles, show that they belong to the same species, remarks that impressions of the heterocercal tail, with the fins of the same species, have been observed—one of them six

feet long; and that the lower lobe of the tail consists of rays that were distinctly ossified.

The Batrachians or Amphibians from the Carboniferous beds, and described by Prof. Cope, are referred by him to the order which he has named *Stegocephali;* an order including the *Labyrinthodonts* Owen, and also Owen's *Ganocephala*, and other species recently described which have been called *Microsaurs*. The species are partly lizard-like, with ribs and limbs (as in *Dendrerpeton*, *Hylonomus*, *Amphibamus*, *Colosteus*, *Archegosaurus*, etc.; and part very long and slender, snake-like, with limbs wanting, as in *Molgophis* Cope, which has ribs and probably no limbs, and *Phlegethontia* Cope, which is without both, and includes "true batrachian snakes,"—one imperfect specimen having 56 vertebræ. Prof. Cope also describes a few Amphibians which he refers to the *Proteida*.

The interesting Subcarboniferous plants brought to light and described by Professor E. B. Andrews, have been already noticed in the last volume of this Journal (p. 462) by the author. The turning out of so many new species of unusual forms in a region that had already been long explored is a fact of much geological interest.

The very numerous plates of this volume are well executed.

Dr. Newberry announces in his Preface that Volume III of the Paleontology will contain a general review of the fossil plants of Ohio, with descriptions of new species; a memoir by Prof. O. C. Marsh, on the *Dicotyles compressus*, and on the *Castoroides Ohioensis;* and notices of other Quarternary vertebrate remains, together with some invertebrate fossils yet undescribed. When completed, the series of Ohio reports will rank among the best State-survey publications that have appeared.

3. *Geological Survey of Alabama. Report of Progress for* 1875; by EUGENE A. SMITH, Ph.D., State Geologist. 8vo, 220 pp.—In this volume, a general outline of the Paleozoic formations of Alabama, with brief descriptions of the various beds, by Prof. Smith, is followed by a summary of the facts heretofore known concerning the Coal-fields of the State, prepared by Mr. T. H. Aldrich. The first systematic attempt at mining and shipping coal, in Alabama, is said to have been made in 1853, near the southwestern extremity of the Cahaba coal-field. Mr. Aldrich's paper includes a reprint of parts of an elaborate essay by R. P. Rothwell, published, two years since, in the Engineering and Mining Journal. The coal-series is said to contain ten or twelve veins [seams] of remarkable thickness, i. e., from two feet (average thickness of clean coal) upward, besides a number of smaller beds, several of which are from fifteen to eighteen inches in thickness. These ten or twelve workable beds are distributed in two series or groups, as we find in all our coal-fields, notably in West Virginia, Ohio and Pennsylvania. * * The *maximum available* thickness of coal as yet proved in any portion of the field will not exceed thirty or thirty-five feet; while, if we take the area of the

Cahaba field at 230 square miles, the *average* thickness of workable coal over the entire field would probably scarcely attain fifteen feet. This estimate, so much lower than we have been accustomed to see stated in reports and newspaper articles, is probably not very different from the thickness which the same method of estimating would give for any of our other bituminous coal fields. "The enormous thickness of the coal-bearing rocks in the Cahaba field, being estimated at over 5,000 feet, has no parallel in the Warrior coal-field." Record of four borings in the Warrior field show sections of from 400 to 600 feet of strata, including four, seven and eleven coal-horizons.

Prof. Lesquereux furnishes a list of 57 species of coal-plants, (of which 12 are named as new,) and remarks upon the very low position in the Coal-measure series to which they must theoretically be assigned, a few species, such as *Sternbergia*, *Lepidodendron Weltheimianum* and *Asterophyllites gracilis*, ranging down even into the Devonian. This corresponds with the suggestions already made, by several geologists, that the coal-measures of the Southern States are all very low in the series, the whole having been called "sub-conglomerate" by some writers. We should prefer, however, some more certain evidence on this point than has yet been produced. The surveys of Alabama, Georgia and Kentucky, now in progress, will leave but a short gap (in northern Tennessee) between the well-known fields of Pennsylvania and Ohio and the southern extremity of the system.

The body of the report is occupied with details of County-work, mostly in the Silurian areas of the State. Some analyses of ores are given, besides lists of elevations. There is also a valuable paper by A. R. Grote, on the cotton-worm (*Aletia argillacea* Hübner) which is preliminary, the author states, to a more extended history of the worm. Mr. Grote writes from observations in Alabama on the habits of the worm, and also from a study of it elsewhere. He is an excellent entomologist, and if his reviews are continued in the survey, will add greatly, by his study of the insects injurious and beneficial, to the value of the State Reports.

We understand that the State appropriation, for the work thus reported on, is only $500 a year to cover the *travelling expenses* of the geologist during the vacations of the State University, in which institution he is a Professor. The volume may therefore properly be accounted a personal contribution to the cause of science.

4. *The Geological Record for* 1874.—An account of works on Geology, Mineralogy and Palæontology, published during the year. Edited by William Whitaker, B.A., F.G.S., of the Geological Survey of England. 398 pp. 8vo. London, 1875. (Taylor & Francis.)—Mr. Whitaker, the editor of the Geological Record, has had able co-workers, and has produced a volume which will be found of great value to all of all lands that are interested in the progress of geological science. The sub-editors are the following, all members of the Geological Society: W. Topley, G. A.

Lebour, F. Drew, and R. Etheridge, Jr., for Descriptive Geology; Professor A. H. Green, for Physical Geology; F. W. Rudler, for Mineralogy and Petrology; and L. C. Miall, Prof. H. A. Nicholson, and W. Carruthers, for Paleontology. The number of works and memoirs mentioned by title is very large, and, for much the larger part, short abstracts are given, which appear to have been carefully prepared. American publications are included, as well as those of other continents, and are judiciously treated. Some omissions we note, of papers in the Publications of Societies. This volume is to be the first of a series of Annual Records, and that for 1875 is already far advanced.

5. *Report on the Geology of a portion of Colorado examined in* 1873; by Prof. J. J. STEVENSON. 376 pp. 4to. Part IV of Lieut. Wheeler's Survey Report, vol. III. Published March 4, 1876.—Prof. Stevenson treats, in his report, of the general physical features of Colorado, of the various rock formations and mineral springs, and of the structure and age of the Rocky Mountain System and brings forward much that is of interest. Under this last head, the new conclusion is advanced that *there was an era of mountain-making in the Rocky Mountains at the close of the Carboniferous age*, synchronous with that in which the Appalachians were formed. The facts brought forward in its support appear to us to be too few and from too limited an area to establish fully its truth against the opposing statements of other Rocky Mountain investigators. If an epoch of mountain-making then occurred, it ought to be registered in an extensive series of obvious facts. We see in the Appalachians—in their breadth exceeding 100 miles, their length several hundreds, with upturnings everywhere—an example of an *individual* mountain-chain (i. e., one made in a single mountain-making operation); and also a display of the manifest evidences of disturbance which such an area should bear. We have, further, an illustration of the fact that such an "individual" cannot have narrow confines, because the crust of the earth has been—certainly since Silurian times—too thick to bend in a narrow trough or geosynclinal (the trough in which the deposits constituting the mountains were accumulated). We shall look with great interest for the results that may hereafter be published by other observers on this interesting question. J. D. D.

6. *Das Gebirge um Hallstatt.* Erster Theil; Die Mollusken-Faunen d. Zlambach und Hallstätter-Schichten. II Heft mit 38 Lith. Tafeln. Von EDMUND MOJSISOVICS von Mojsvár, Chef-Geologen d. k. k. geol. Reichsanstalt. 4to. Vienna, 1875.—This part of the great work on the peculiar fossil fauna of the renowned locality of Hallstatt is worthy of its predecessor previously noticed in this Journal. It contains the most complete series of figures and descriptions of the genus Arcestes yet published. Thirty-four plates are devoted to the illustration of this group and the specimens are, for the most part, very perfect. This has enabled the author to exhibit a very perfect series of a multitude of various forms all

having perfect apertures, and his plates are the most perfect demonstration, which we have yet seen, of the importance of the contours of the aperture in the classification of sub-groups. The author divides the genus Arcestes into several divisions according to the peculiarity of the sutures and gives complete tables of the geological and geographical distribution of the species. In fact the stratigraphical paleontology is treated in the most perfect manner. Any criticisms of the zoology of the work would be out of place and inapplicable, since it is essentially, as are all the later German paleontological memoirs on this and kindred subjects, paleontological geology; the differences of the animal remains being invariably the aim of all the researches, with the view of establishing data by which the different strata may be distinguished one from another, and the peculiarities of the faunæ noted. Two new genera are described, Didymites and Lobites. The latter being related to the true Arcestes in about the same way that Scaphites is to the typical Ammonites. Whether this will eventually hold or not is doubtful, since, as Quenstedt has shown in his master-work on the Jura, such forms are intimately connected with normal forms, sometimes not even specifically separable according to the generally accepted methods of classification. A. H.

7. *Rammelsberg: Handbuch der Mineral-Chemie.* 2d edition, 980 pp. 8vo. Leipzig, 1875.—The second edition of Rammelsberg's valuable work on mineral chemistry is an indispensable volume to all interested in the progress of mineralogy. The general plan adopted by the author is essentially that of the first edition (published in 1860), the most important changes being those which strict conformity throughout to the principles of the new chemistry has required. The first volume (136 pp.) contains the general treatment of the subject of mineral chemistry, with a detailed discussion of the principles of isomorphism and heteromorphism. The second volume (744 pp.) takes up the mineral species in order, giving under each the most of the analyses published, especially those of recent date. For each analysis the atomic ratios of the different elements have been calculated in full, and from them the formulas are deduced. The author has been so long an authority in mineral chemistry that his present conclusions on many disputed points, though occasionally appearing somewhat arbitrary, will have great weight with all. E. S. D.

8. *Einleitung in die Krystallberechnung*, VON CARL KLEIN; *zweite Abtheilung*, pp. 209–393. Stuttgart, 1876.—The first part of Professor Klein's valuable work on crystallography was noticed in a recent number of this Journal, (III, xi, 68.) The present part includes a detailed description of the methods of calculation applicable to the monoclinic, triclinic, and hexagonal systems, the whole being characterized by the same clearness and thoroughness to which attention was before called. A chapter upon the drawing of crystals forms the conclusion of the work. E. S. D.

III. BOTANY AND ZOOLOGY.

1. *Phænological observations in Giessen;* by H. HOFFMANN. (*Phänologische Beobachtungen in Giessen,* von H. Hoffmann.) —We do not know any single English word for the kind of observations here recorded, and therefore we shall adopt that which our author has borrowed from Greek. This pamphlet of 32 pages gives the date when the leaf and flower-buds of over two hundred plants opened; the fall of the blossom; the ripening of the fruit, and the fall of the leaves. The observations in some cases extend through twenty years or more. The author has also noted the dates of the appearance of butterflies, birds, etc. The author submits his work as a contribution to the store of facts required by the student of vegetable climatology, but does not give any conclusions of his own except the following:

In the case of plants in a given locality, the average of a few years is very nearly the same as the average of many, e. g.:

The "first flowers" of the following species appeared on the days given below as means:

Average	of 8 years,	of 13 years.
Geranium sylvaticum,	20 May,	19 May.
Triticum vulgare,	"	"
Average	of 15 years,	of 21 years.
Helianthus annuus,	26 June,	25 June.
Average	of 9 years,	of 14 years.
Primula elatior,	25 March,	25 March.

In only one of the cases collated is there to be observed a difference of more than one day.

Prunus avium, average of	8 years,..........	23 April.
"	14 "	21 "
"	21 "	19 "

G. L. G.

2. *Bulletin of the Bussey Institution, Harvard University.* Part V. 1876.—This finishes the first volume, of 453 pages, and is therefore properly supplemented by a copious index. In articles No. 18, 19, and 20, Prof. Storer continues his valuable and practical chemical papers—the notice of which we leave to another hand. Papers No. 21 to 24 are by Prof. W. G. Farlow, as follows:

On a Disease of Olive and Orange Trees occurring in California in the spring and summer of 1875.—It proves to be the work of a fungus, *Fumago salicina,* which has been known and given trouble in Europe since the year 1829. In an excellent plate Prof. Farlow represents the stylospores, mycelium, pycnidia, and conidia.

On the American Grape-Vine Mildew.—It appears that the *Oidium Tuckeri,* which has been so disastrous to the vines of

Europe and Madeira, and which is "the conidial form of some species of the *Ascomycetes*, probably some *Erysiphe*," although supposed to have come from America, is not a common or conspicuous infestor of our native vines; but that the commonest, at least in New England, is *Perenospora viticola*, which is limited to the leaves and stems, and does not attack the fruit. Being often found on every leaf, of a vine, it would be expected to injure the grape crop. "Such, however, is not the case. The fungus does not attack the grapes themselves, nor does it, at least in New England, appear until about the first of August, and its withering effect upon the leaves is not very evident before September. As far as out-of-door grape culture in the northern States is concerned, we are inclined to believe that, practically, no harm is done by *Perenospora viticola*, but that, on the contrary, the fungus is really beneficial. Our native vines have a luxuriant growth of leaves; and the danger is that, in our short summers, the grapes may not be sufficiently exposed to the sun to ripen. But the *Perenospora* arrives, with us, at a time when the vine has attained its growth for the season, the important point being then to ripen up the grapes which are concealed by the foliage. By the shriveling of the leaves, the *Perenospora* enables the sun to reach the grapes without loss to the vines, as is shown by the fact that the vines continue to live on, year after year, without apparent injury." The botanical history, literature, and forms of this fungus are fully illustrated, two plates show the structure and fructification of this and some allied species; and a synopsis of the half-dozen species of *Perenospora* detected in the United States, and five of *Cystopus*, is appended.

List of the Fungi found in the vicinity of Boston. Confined to the species which have come under the author's own observation.

The Black Knot (of Plum and Cherry trees). This interesting and important memoir is illustrated by three beautiful plates, showing this disease in various stages, and the whole structure, development and fructification of *Sphoria mortosa* of Schucinitz, the fungus which produces this black knot, which so deforms and injures plum and cherry trees throughout the Northern States and Canada. The remedy is the knife or the axe. For prevention Dr. Farlow recommends the extirpation of choke cherry trees, upon which the pest largely breeds in the vicinity of Boston. Farther west it would all the more be necessary to destroy all the wild plum-trees (*Prunus Americana*), which are fearfully infested.

No. 25, the last paper of the volume, is Prof. Sargent's

Report of the Director of the Arnold Arboretum;—from which we learn that: "Probably over 100,000 ligneous plants have been raised during the nine months," and as many as 5,542 trees and shrubs have been presented to various establishments and individuals throughout the United States interested in agriculture," besides those sent to Kew and elsewhere abroad. A catalogue of the species raised is appended. A. G.

3. *Nymphæa flava* Leitner.—The plate of Audubon's great work which represents the American swan likewise represents the flower of a yellow *Nymphæa*, or true water-lily, under the above name. The foliage which accompanies it may be that of a *Nuphar*, but the flower is that of a *Nymphæa*. Leitner was a German botanist who explored southern Florida, and died or disappeared there, —if we rightly remember, was thought to have been killed by Indians. He doubtless met Audubon and gave him the name which he published on his plate. The species has properly been left unnoticed so long as the whole evidence of its existence rested upon Audubon's figure of a flower accompanied as it is with *Nuphar* foliage. But of late years we have heard of a yellow water-lily in Florida. In 1874, Dr. Edward Palmer sent us a specimen with foliage and flowers collected in Indian River, and certified to the yellow color. It has now been detected by Mrs. Treat, on the St. John's River, and living plants communicated to us, from which we may expect to see fresh blossoms. The growth is very different from that of *N. odorata*, the rhizoma being shorter, and thickly beset with salient blunt tubercles; and the plant propagates freely by stolons. A. G.

4. *Note on some of the Starfishes of the New England Coast;* by A. E. Verrill.—In the Archives de Zoologie Expériméntale et Générale, vol. iv, Nos. 2 and 3, 1875, M. Edmond Perrier has published a very useful and important paper entitled "*Révision de la Collection de Stellérides du Muséum d'Histoire Naturelle de Paris*," in which he has redescribed many of the types of Lamarck, J. E. Gray, Müller and Troschel, and others, as well as many new species, and has also added many remarks on various genera and species, as well as upon their classification, etc. At the present time I do not propose to discuss this memoir, as a whole, but wish to call attention to some errors into which the author has fallen concerning our common New England species, owing chiefly, doubtless, to his not having a sufficient number of well preserved specimens to form any clear ideas of their true specific characters and great variability.

Every naturalist who has occasion to collect and study any considerable number of living specimens of any of the larger species of *Asterias*, especially if from different localities or varying stations, must be deeply impressed by their extreme variability, not only in size and color, but in the form and relative length of the rays, character of the dorsal spines, number of pedicellariæ, etc. Moreover, if he has had occasion to preserve large numbers of specimens, both in alcohol and by drying, he must have observed the very different forms and appearances that specimens, quite similar when living, will assume, whether owing to the various states of contraction in which they die, or to the mode in which they are afterwards preserved. Thus similar living specimens may be killed and preserved so that one will have slender tapering rays; another, rays smaller in the middle and constricted at base; another, rays swollen at base and pointed at

tip; some will die with swollen disk; others with contracted disk; some will have the rays collapsed and flattened; others will have them round and plump, or angular; some will have the spines erect; others, more imperfectly preserved, will have them flattened down and more or less detached. Moreover, the plates in some will be so closely drawn together by the contraction of the muscles of the skin as to give them a rigid character, while others, perfectly identical. if they die in a relaxed or inflated condition will have the plates separated by the looser integuments so as to give them an openly reticulated appearance, with wider naked spaces between the plates. Hence all such characters should be used with great caution.

It is, therefore, evident that any naturalist who would correctly limit the species in this group should at least have a very large number of specimens preserved, as well as possible, in various ways, and still better, when possible, he should collect large numbers of the living specimens and after studying them in life and making notes upon them he should preserve, and afterwards compare them with his notes. In this difficult group there are probably no species more variable and perplexing than those forms allied to *Asterias rubens* of Europe, and *A. vulgaris* and *A. Forbesii*, the common New England species. And yet in this very group M. Perrier attempts to decide the specific characters of our species, and to correct their synonymy after an examination of very few (sometimes only one), and often very badly preserved dry specimens (*A. pallidus*). And in doing this he relies on characters that are notoriously variable, and even upon those accidental features due to modes of preservation, as stated above.

As M. Perrier particularly refers (pp. 354–7) to my own views in regard to our native species, as expressed in several former papers,* and seems to think it strange that my conclusions in 1873 differed slightly from those held in 1866, I may be pardoned for stating that during the ten years that have elapsed since my first paper on the subject was published, these starfishes have been collected, studied, and preserved by me in very great numbers, and from hundreds of localities, during the various dredging expeditions that I have undertaken along our coast, some of which have been noticed in former volumes of this Journal. Therefore, having carefully examined many hundreds of specimens, in all conditions, and having taken ten years to consider the matter and to discuss it with others, I feel perfectly confident that M. Perrier has made at least five American "species" out of specimens that actually represent but two. These errors would have been more excusable had they not been made subsequently to my revision of the synonymy, for he might have supposed that my materials were far more ample than his own. The facts are as follows: Upon the coast of New England there are, as yet known,

* Proceedings Boston Society of Natural History, vol. x, p. 333, 1866; Report on the Invertebrata of Southern New England, Report of U. S. Commission of Fish and Fisheries, Part I, 1873 (published March, 1874).

but three species of *Asterias*, belonging to the littoral zone and shallow waters, though two or three other smaller species (*Leptasterias*) occur in deep water.* One of the shore species, *A. littoralis* (Stimpson), is a small species, rarely six inches in diameter, (belonging to the group, *Leptasterias*) found in the Bay of Fundy and northward to the Gulf of St. Lawrence, both between tides and in deep water, and although variable in form, size, color, etc., it has not yet led to much confusion. The two others are large and very common species—one southern and the other northern—but with their respective areas overlapping on the New England coast. One of these, *A. Forbesii* (Desor), extends from the Gulf of Mexico, to Casco Bay, Maine, and is the most common species on the southern coast of New England. The other, *A. vulgaris* (Stimp.), extends from Labrador (and probably farther north) to Long Island Sound, where it becomes rare; it is the most common species north of Cape Cod, and is very abundant on the coast of Maine and northward. Both species vary extremely in size, form, and color, even when living, and still more so when preserved by drying. The color of the faded dry specimen, which M. Perrier mentions as distinguishing "*A. Fabricii*" from "*A. berylinus*," is a perfectly worthless character, yet when living our two species can usually (but not always) be distinguished by the colors, for *A. Forbesii* (*berylinus*) is generally greenish, varying to orange and brown, with a bright orange madreporic plate; while *A. vulgaris* is usually reddish, purplish, or violet, varying to yellow and brown, but with a pale buff or cream-colored madreporic plate. Moreover, the colors and forms of each vary according to the sex, and the form varies according to the season, state of the ovaries, age, dilation with water, etc. The *forms* of the major pedicellariæ,† and of the adambulacral (or interambulacral) spines give the most available characters for distinguishing the two species under all circumstances, though the firmer skeleton of *A. Forbesii* is also an important and characteristic feature.

In A. Forbesii the major pedicellariæ are short, ovate, blunt-pointed, hardly longer than broad; the adambulacral spines are stout, obtuse, and in most cases many are more or less flattened, and grooved externally, at tip.

* It is proper that I should state that I have become satisfied that the species described by me as *A. Stimpsoni*, in 1866, was not well founded. The study of a far more extensive series of specimens has shown that the specimens thus named were somewhat peculiar small specimens of *A. vulgaris* (Stimp.), with which some young specimens of *A. littoralis* were also confounded, so that the characters given largely appertain to the young of *A. vulgaris*. It is probable that most of the specimens formerly distributed as *A. Stimpsoni*, were young of *A. vulgaris*, and such may have been those that M. Perrier says he has examined, though he considers it a good species.

† Dr. Stimpson, in 1862, (Proc. Boston Soc. Nat. Hist., vol. viii, p. 262, *note*) called special attention to the two peculiar forms of pedicellariæ, characteristic of this family, and to their importance in distinguishing the species. He termed the larger sessile ones, whether scattered over the surface or attached to the ventral spines, "*major pedicellariæ*," and the small pedunculate ones, borne in clusters on the spines, "*minor pedicellariæ*." In 1864–70 M. Perrier called the former, "*pédicellaires droits*," and the latter "*pédicellaires croisés*."

In A. vulgaris the major pedicellariæ are lanceolate, sharp-pointed, much longer than broad; the adambulacral spines are longer, more pointed, and seldom flattened.

The dorsal spines are variable in form and number in both species, but are usually more acute in the latter, though blunt and even clavate spines often occur on both species. The *number* of *minor* pedicellariæ on the spines, and of *major* ones on the back and also on the adambulacral spines, is extremely variable in both species. Yet these are the characters mainly relied upon by M. Perrier for distinguishing his supposed species. Three of the "species" recognized by him are evidently mere forms of *A. vulgaris.* These are *A. Fabricii* (Agassiz, MSS.), based on *one* dry specimen from Laborador; *A. pallidus* (Agassiz, MSS.) based mainly on six small dry specimens, sent, like the preceding, from the Museum of Comparative Zoology in 1864, and in a very bad state of preservation, the spines being mostly detached by partial decomposition during the drying of the specimen (which has misled M. Perrier, who imagined that they had been moveably articulated); and two large specimens that he refers to *A. vulgaris*, one from Beverly, Mass., and one in the British Museum. The latter was probably sent by Dr. Stimpson, who commonly used labels marked "Exploration of the East Coast of the United States" (not "west" coast, as M. Perrier gives the label), for his New England collections. I had given "*A. Fabricii*," after examining original specimens, as a synonym of *A. vulgaris* in my paper of 1866; and gave "*A. pallidus*" as an undoubted synonym in my Report of 1873–4. All the characters given by M. Perrier as distinctive are variable and partly accidental features that can be found, with all intermediate states, in any considerable collection of this species from a single locality. These manuscript names were given by Prof. L. Agassiz before he had made a very thorough study of the genus, but in a conversation, in 1871, while we were dredging in company in Vineyard Sound and obtaining both species in abundance, he fully agreed with me that there were *only two* large species of this group known on our coast, and he also positively identified the numerous good specimens of *A. vulgaris* with his *A. pallidus;* and likewise the *A. Forbesii* (or *arenicola*) with his *A. berylinus.* Dr. Wm. Stimpson in a conversation with me not long before his death, also agreed with these decisions. Had M. Perrier examined a good series of specimens he also would surely have found it impossible to have made the useless distinctions that he now proposes, based on such very insufficient material. In my Report of 1873–4 I stated that *A. Forbesii* and *A. arenicola* are "probably identical," the differences noticed (mainly in form and color) "being, perhaps, chiefly sexual," but not desiring to make premature changes, I left them under the two names, only because I had then no time to determine whether the differences are sexual, or properly varietal, or due to local or individual variations. Subsequent studies have satisfied me that the differences are mainly individual or casual and very incon-

stant, so that there is no longer any reason for distinguishing the two even as varieties, yet M. Perrier not only keeps them distinct, as two species, but names another slight variation as a distinct variety of *A. arenicola*.

There is now little doubt in my mind that *A. vulgaris* will prove to be identical with *A. violaceus* of Northern Europe, and that the latter may be, as many believe, a mere variety (or sexual form) of *A. rubens*. But M. Perrier considers these distinct species, though with some doubt as to *A. violaceus*.

That, in other cases, he has admitted, as valid species of *Asterias*, forms that are scarcely varietal is very probable, judging from his descriptions alone, for the distinctive characters that he gives are frequently those that are most apt to be variable. He has described a single dry Labrador specimen of *A. polaris* (from Dr. Packard's collection) as a new species under the name of *A. borealis*. But among a large number of fresh specimens observed by me at Anticosti Island, there were various forms intermediate between his specimen and what he regards as the typical *A. polaris* from Greenland. Moreover, the several Labrador specimens that I have examined, collected by Dr. Packard at the same time with the one now described as *A. borealis*, show great variations in the form of the spines, length of arms, and number of pedicellariæ,—characters that M. Perrier regards as distinctive in this case. Therefore there is good reason to believe that his *A. borealis* is only a form of *A. polaris*, to which American zoölogists have hitherto referred it.

Throughout the paper there are numerous typographical errors, many of them due to imperfect proof-reading, but others more important are due to careless references to the papers of other writers, especially those in English. "Contributions to the Zoology of Yale College" is scarcely a legitimate substitute for the "Contributions to Zoology from the Museum of Yale College," published in this Journal. The locality, Eastport, Maine, is once given as "East Port (Massachusetts,)" and once as "East Port, (Canada.)"

In one respect the nomenclature adopted, in some cases, by M. Perrier is very objectionable, for he attempts to restore some of the ante-Linnæan "names" of species used in 1733 by Linck, who was not, in any sense, a binomial writer, and whose polynomial (or accidentally binomial) phrases can have no claim to priority, as specific names, under the binomial system.

5. *Hæckel's theory* (*Alloœogenesis*) *of the genetic connection between the Geryonidæ and Æginidæ.*—In the Proceedings of the Elliot Society for 1857, McCrady gave a very interesting account of the commensalism of the young brood of a Cunina and of Turritopsis. No notice was taken of this remarkable mode of development, McCrady's observations having been discredited by the later publication (1865) of a magnificently illustrated memoir on the "Rüssel-quallen" by Hæckel. The startling hypothesis of the genetic connection between the Geryonidæ and Æginidæ contained

in this memoir and called by Hæckel allœogenesis, has been ever since a stumbling block to all theories of genetic relationship among Medusæ.

Two short papers recently published, the one by Schulze (Nat. Wiss. Ver. f. Steiermark, 1875, p. 125), and the other by Uljauin (Archiv f. Naturg., 1875, p. 333), have, however, proved conclusively that Hæckel's theory, like many other of his vagaries, had no foundation of truth. It was based not merely on an incorrect interpretation of facts, but the facts themselves existed only in his imagination.

As, perhaps, with the exception of his monograph of the Radiolaria, no other memoir has contributed more than the one above quoted to give Hæckel the position he holds among zoölogists, we may be allowed to remind the Hæckelian school of naturalists that this same genetic connection has furnished the text for many a sermon from their high priest. Infallible himself, he has been unsparing in his condemnation of the ignorance and shallowness of his opponents. Proved now to be in the wrong, we expect therefore justice without mercy from this stern scientific critic, and look forward in the next number of the Jenaische Zeitschrift for a thorough castigation of Hæckel by Hæckel, showing up the absurdity of allœogenesis and all that hangs thereby.

ALEXANDER AGASSIZ.

6. *Animal Parasites and Messmates;* by P. J. VAN BENEDEN. 274 pp. 12mo, with 83 illustrations. 1876. New York. (D. Appleton & Co.) The International Scientific Series.—The author of this work is an able Belgian zoologist, well versed in the subject of which he writes. The subject is treated in a popular style, and cannot fail to interest. The facts presented are some of the strangest that have been brought to light by recent investigations, and not the least marvelous are those relating to man's parasites.

7. *The Journal of Anatomy and Physiology*, conducted by G. M. HUMPHREY, M.D., F.R.S., Prof. Anat. Cambridge, Wm. Turner, M.B., Prof. Anat. Edinburgh, M. Foster, M.D., F.R.S., Prælector Physiol., Cambridge, and Wm. Rutherford, M.D., Prof. Inst. Med. Edinburgh. January, 1876, vol. x; part II, pp. 223–458, with 8 plates. Cambridge and London. (MacMillan & Co.)—The tenth volume of this able scientific quarterly commenced in October. The January number, recently issued, contains the following papers: On the anatomy of the lens, by Dr. Thin and J. C. Ewart (pl. ix); anatomy of the Lineidæ (Nemerteans), by Dr. McIntosh (pl. x–xiii); experiments on the biliary secretion of the dog, by Dr. Rutherford and M. Vignal; the transformations of the pulse-wave in the different arteries, by Dr. Galabin (pl. xiv); on the broncho-œsophageal and pleuro-œsophageal muscles, by Dr. Cunningham; the summation of electrical stimuli applied to the skin, by Dr. Stirling; development of Elasmobranch fishes, by F. M. Balfour (pl. xv, xvi); craniofacial apparatus of Pteromyzon, by Prof. Huxley (pl. xvii, xvii); secondary arches of the foot,

by S. M. Bradley; note on the placental area in the cat's uterus after delivery, by Prof. Turner; notices of books; report on the progress of anatomy, by Prof. Turner and D. J. Cunningham, M.B.

8. *Bulletin No.* 2, of the U. S. Geological Survey of the Territories, contains two papers by R. Ridgway, entitled Studies of the American Falconidæ, and Ornithology of Guadeloupe Island, illustrated by two plates.

III. ASTRONOMY.

1. *Observations of the planet Jupiter.*—The Royal Astronomical Society of London have appointed a committee whose object shall be to endeavor to enlist observers in making drawings of the appearance of the planet Jupiter, and to obtain as extensive a series as possible of such drawings. The committee has issued a circular, and prepared, for the sake of uniformity and convenience, blank forms upon which the drawings can be made. Drawings and communications should be sent to the "Secretary of the Jupiter Committee," Royal Astronomical Society, Burlington House, London, W.

2. *Repertory of works in Pure and Mixed Mathematics.*—Doctors KŒNIGSBERGER and ZEUNER of Dresden, propose to collect, as far as possible, and publish "longer or shorter detailed reports written by the authors themselves upon their own books and treatises" in the mathematics. The reports will comprise articles on the entire field of mathematical research: Pure mathematics, and all the collateral branches of the mixed science, such as: astronomy and geodesy, mathematical physics, analytical and technical mathematics, all mathematical branches of engineering, mathematical statistics, etc.; besides which the editors intend to have the reports printed in the language in which they are sent to them by the author, taking it for granted that such reports in German, English, French, or Italian will be intelligible to scientific men of all countries.

They propose to begin with reports on all books and memoirs which have appeared since Jan. 1st, 1875. The "Repertory" will at first be issued in numbers, at irregular intervals. H. A. N.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *The American Cyclopædia.* Vol. xv. SHO–TRO. D. Appleton & Co., New York. 1876.—The first volume of this edition of Appleton appeared in July, 1873. One volume more will complete the work, making in the aggregate nearly 15,000 pages of text. Among the articles in the fifteenth volume interesting to scientific readers we note particularly *steel*, by Dr. Droun; *silver*, by Dr. Raymond; *sound*, *spectrum* and *stereoscope*, by Professor Mayer; *sun*, by Professor Langley; *tides*, by Mr. Hilgard; *snow*, *storms* and *trade-winds*, by Cleveland Abbe; *telegraph*, by Professor Lovering; steam, steam-boiler, carriage, engine and navi-

gation, and strength of materials, by Professor Thurston. Numerous astronomical articles are furnished by R. A. Proctor, of London: e. g. spectrum analysis, sun (in part), &c. The medical and physiological articles are mainly by Dr. J. C. Dalton, while other well-known names add authority to the contents of this volume. We have in former notices called attention to the large amount of special work performed for this edition of Appleton's Cyclopedia by men of acknowledged ability and original research in the departments of which they treat. The foregoing list is in evidence that this character is fully maintained. The maps and wood-cuts are numerous and excellent in quality. B. S.

2. *Annual Report of the Light-House Board to the Secretary of the Treasury for the year* 1875. 136 pp. 8vo. Washington, 1875.—The executive members of the Light-House Board are Professor Henry, Commander J. G. Walker, U. S. N., Naval Secretary, and Major P. C. Hains, Engineer Secretary. The report for 1875 contains "an Account of the investigations of the Light-House Board relative to illuminating materials, by the Chairman of the Committee on Experiments." Lard-oil had been in former experiments found to be the best illuminating oil; and this conclusion is sustained as regards the large lamps by new comparisons of lard oil with the best mineral oil, though not as regards the smaller. On account of the increased expense of lard oil, the mineral oil will hereafter be introduced. There is also another of Professor Henry's valuable papers containing the "Investigations of the Board relative to sound in its applications to fog-signals," made under his direction in 1875.

3. *Meter-Diagram.*—Messrs. A. & T. W. Stanley, of New Britain, Conn., well known as makers of accurate measures of length, levels, etc., have lately prepared a neat meter-diagram, printed on heavy paper faced with linen, with the scales and tables on both sides, and 4½ inches wide. It gives in a complete manner the entire metric system, with the relations of feet and inches to the meter and its subdivisions, and in the appended tables the equivalents in denominations in use, with rules for conversion. Professor Newton says of it: "I know of no easier way by which anyone desirous of learning the system can do it, than by studying this scale, and keeping it in a place where he will frequently see it." It is put up in a paper case, and sold at the moderate price of three dollars per dozen, for use in schools, etc.

Handbook of Architectural Styles. Translated from the German of A. Rosengarten by W. Collett Sandars. 502 pp. 8vo, with 639 illustrations. 1876. New York. (D. Appleton & Co.)—An excellent, and profusely illustrated work.

A Short History of Natural Science and of the Progress of Discovery from the time of the Greeks to the Present Day, for the use of Schools and Young Persons; by Arabella B. Buckley. 488 pp. 12mo, with illustrations. 1876. New York. (D. Appleton & Co.)—An instructive work.

Physics of the Ether. By S. Tolver Preston. London. (E. and F. N. Spon.) 1875. 8vo, pp. 136.

Geological Survey of Pennsylvania. Report of Progress in the Clearfield and Jefferson District of the Bituminous Coal-field, by F. Platt, 296 pp. 8vo, with maps and sections.

OBITUARY.

A. R. Marvine.—Mr. Archibald R. Marvine, the geologist, died in Washington, March 2d, 1876. He was born at Auburn, N. Y., Sept. 26, 1848, and while a youth attended the military school at Sing Sing, and subsequently the School of Technology at Philadelphia. He then entered the Hooper Mining School of Harvard University, from which he graduated in 1870, when he was appointed instructor in the same school, a position which he held until July, 1871. He was one of the students who went with Professor Whitney, to make practical studies in geology and geography in the Park Mountains of Colorado, in 1869.

In the summer of 1870, Mr. Marvine was appointed assistant-geologist to attend the celebrated Santo Domingo Expedition, and on his return he prepared a brief report on the geology of the island, which was published, with the other reports relating to Santo Domingo affairs, by order of Congress.

In July, 1871, he received the appointment of astronomer to the Wheeler Expedition, in which capacity he served several months, while that work was in progress, and then continued as a member of the Expedition in the capacity of geologist. His report on the geology of a district of country through which he passed, embraced in southern Nevada, northwestern Arizona, and southern California, has lately been published by authority of Congress.

His next geological work was in the Keweenaw copper region on the shore of Lake Superior, under the direction of Professor Pumpelly, and his report was published by authority of the legislature of Michigan.

In March, 1873, he was given a position as geologist in the corps of the U. S. Geological and Geographical Survey of the Territories under Dr. Hayden. In this capacity he made a careful survey of a region embracing Middle Park and extending eastward across the Front Range to the foot hills. His published report on this work gives evidence of thorough preparation, great labor and much skill, in the collection of material, and ability in its use. After preparing his report on the Middle Park district, he returned to Colorado Territory for the purpose of extending his investigations into a region of country west of Middle Park on the headwaters of the Grand, White, and Yampa rivers, and entered into his labors with great vigor and enthusiasm. But a long summer of toil and privation in that wilderness of cañons, crags, and peaks, undermined his health, and shortly after his return, early in the winter of 1874–5, he was prostrated with an attack of rheumatic meningitis from which, after many weeks of suffering, he partially recovered, but was not again able to resume his work, and early in December last he relapsed into a condition that was soon found to be hopeless.

Mr. Marvine leaves behind a large circle of friends, among the working scientists of the country, who had learned to expect great and valuable results from his researches. G. K. G.

APPENDIX.

ART. LIII.—*On some Characters of the genus Coryphodon* Owen; by O. C. MARSH.

THE lower Eocene deposits of England and France have yielded a few remains of an interesting genus of ungulate mammals to which Owen, in 1846, gave the name *Coryphodon*.* Hébert subsequently published a memoir on the subject, in which he figured and described the more important specimens found in France.† Although comparatively little is yet known in Europe of the structure or near affinities of these animals, the portions preserved are characteristic, and the genus is well marked. The geological horizon, also, is fully determined, viz: the London clay of England, and, in France, the base of the *Argile plastique*.

While in Wyoming with the Yale College exploring party in 1871, the writer had his attention called to a deposit at the base of the Eocene containing mammalian remains, and subsequently obtained a number of the fossils, mainly through the kindness of Wm. Cleburne, Esq., who sent other specimens to the Academy of Natural Sciences in Philadelphia. Some of the latter fossils were described by Prof. Cope as *Bathmodon radians* and *B. semicinctus;* and in the same paper another generic name, *Loxolophodon*, was proposed for the same lower molar named as the second species.‡ Since this time, other similar remains have been found in Utah and New Mexico, and their principal characters can now be determined.

An examination of an interesting series of these fossils now in the Yale Museum, including some portions of the same individuals described by Prof. Cope, clearly shows that they all belong to the genus *Coryphodon* of Owen. This is especially important, as the geological horizon of the remains is essentially the same in both countries, and the American specimens promise to clear up many doubtful points in regard to the animals themselves. One of the specimens in the Yale collection is a nearly perfect skull, representing an undescribed species

* British Fossil Mammals and Birds, p. 299.
† Annales des Sciences Naturelles, tome vi, p. 87, Plates III and IV, 1856.
‡ Proceedings American Philosophical Society, p. 420. 1872.

which may be called *Coryphodon hamatus.* It indicates an animal somewhat larger than a tapir. The more important characters derived from an examination of this cranium, and some other remains of the same genus, are as follows:

The skull is elongated, the facial portion being most produced. A basal line extending from the lower margin of the foramen magnum along the palate to the end of the premaxillaries is nearly straight. The zygomatic arches are much expanded, but the malar is comparatively slender, and joins the maxillary in front of the orbit. The latter is of moderate size, and confluent with the large temporal fossa. The general form of the skull is indicated in the cut given below, figure 2. The maxillaries are massive, and on the sides behind the canines are deeply indented, giving a marked constriction to this part of the skull. The lachrymal forms the anterior border of the orbit, and its foramen is inside the orbital margin. The nasals are quite slender in front, and broad posteriorly. The premaxillaries are expanded transversely, giving a wide anterior narial aperture. The anterior palatine foramina are small, (figure 2.) The posterior nares extend forward between the last upper molars. The dental formula is as follows:

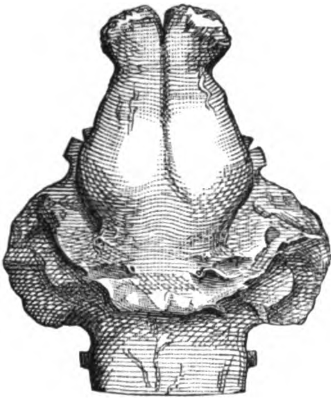
$$\text{Incisors } \frac{3}{3};\ \text{canines } \frac{1}{1};\ \text{premolars } \frac{4}{4};\ \text{molars } \frac{3}{3};\ \times 2 = 44.$$

The teeth agree in all generic characters with those figured as *Coryphodon* by Owen and Hébert. The occipital condyles are well separated, and there is a condylar foramen. Between the basisphenoid and the periotic, there is a large opening, partially due to the divergence downward of the inner faces of the latter bones. There is a strong paroccipital process, and a postglenoid process, which varies in size in different species. In *Coryphodon hamatus*, it is long, and curved forward, and to this the specific name refers. The skull as a whole presents strong Perissodactyle characters.

The brain cavity in *Coryphodon* is perhaps the most remarkable feature in the genus, and indicates that the brain itself was of a very inferior type. It was quite small, as in all Eocene mammals, but its most striking features were the small size of the hemispheres, and the large expanded cerebellum. The form and relative size of these are shown in the accompanying cuts, figures 1 and 2.

The olfactory lobes were large, and entirely in advance of the hemispheres. They were bounded in front by a well ossified cribriform plate, and partially separated by a vertical bony septum. The cerebral lobes were ovate in form, and very small, a transverse section exceeding but little that of the medullar opening. In shape and relative size, the hemispheres and olfac-

1.



2.

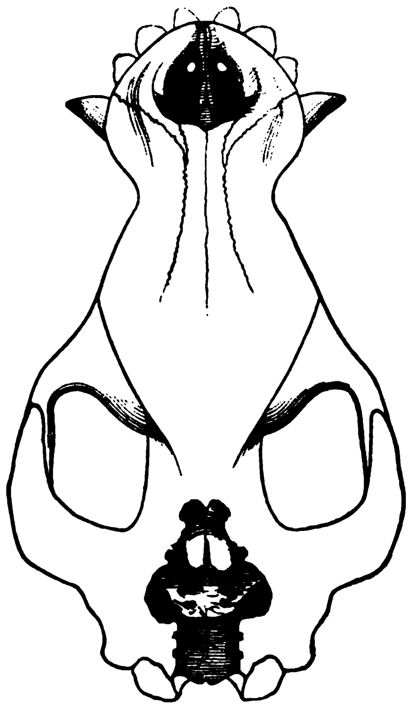


Figure 1.—Cast of brain-cavity of *Coryphodon hamatus* Marsh; top view. One-half natural size.

Figure 2.—Outline of skull and brain-cavity of *Coryphodon hamatus*; top view. About one-fifth natural size.

tory lobes of this genus are somewhat similar to those of *Dinoceras*. The cerebellum was proportionally large, and widely expanded transversely. Its peculiar form is shown in figure 1, which is drawn from a cast of the brain-cavity of *C. hamatus*. This portion of the brain nearly or quite equaled the hemispheres in size, thus differing widely from any known mammal. There is a well marked pituitary fossa, but no clinoid process. The foramina for the exit of the optic nerves are small, but for the others very large. The brain as a whole was very low in grade, and precisely such as might be expected in a mammal from the oldest tertiary deposits.

The skeleton of *Coryphodon* (*Bathmodon*) presents many features of interest, but only a few can now be mentioned. The limbs were comparativly short, and the femur has a third trochanter. The feet are especially interesting, as they present a primitive or generalized type. The manus and pes had each five short digits.*

The various characters shown in the skull and limbs of *Coryphodon* indicate that the animals of this genus were essentially five-toed Perissodactyles. They evidently represent a distinct family which may be called *Coryphodontidæ*. Their geological horizon in this country is near the base of the Eocene, in the deposits named by the Survey of the Fortieth Parallel, under Clarence King, the Vermillion Creek series. The remains of the family at present known in this country are from Utah, Wyoming, and New Mexico.

Yale College, New Haven, April 15th, 1876.

*** Prof. Cope has recently published (Catalogue of Eocene Vertebrata from New Mexico, p. 28, 1875), a figure of the "Hind foot of *Bathmodon*," which is incorrect in several respects, the hallux, for example, having *three* phalanges!**

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

Art. LIV.—*Note on the Duplicity of the* "1474" *line in the Solar Spectrum;* by Professor C. A. Young.

The line "1474" is the one which is reversed in the spectrum of the Solar Corona, and coincides with one of the short lines in the spectrum of iron. In the iron spectrum it is brought out, however, only by the Leyden jar spark, and not by the electric arc between carbon points. As seen in the solar spectrum, with ordinary, or even very powerful, spectroscopes, it appears like a fine, hard, black line.

In examining this portion of the spectrum recently with a diffraction spectroscope, armed with a silvered glass "gitter-platte" of 8640 lines to the inch, for which I am indebted to the kindness of Mr. Rutherfurd, I find this line to be unmistakably double; the two components are separated by a distance of only about $\frac{1}{7}$ of a division of Ångstrom's scale, i. e. about $\frac{1}{40}$ of the distance of the D lines. The more refrangible component is heavier than the other and slightly winged or hazy at the edges, while the other is narrower and better defined. The more refrangible line is undoubtedly the real corona line, and the other belongs to the spectrum of iron, the close coincidence being merely accidental.

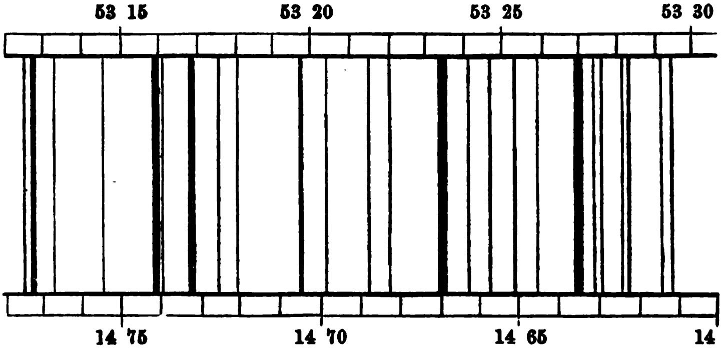
As long ago as 1870 I suspected the bright 1474, as seen on the limb of the sun, to be very slightly more refrangible than its dark analogue (the position of which with insufficient dispersive power would apparently correspond to the *mean* of the two components); and the suspicion has recurred from time to time on many occasions since then, while there has not been a single instance in which the bright line appeared to fall *below*

the dark one. Still there has never seemed to be sufficient evidence to warrant a positive assertion. Examination with a speculum metal "gitterplatte" of 6480 lines to the inch, some two years ago, suggested the idea that the dark line might be closely double, but the definition of the grating was not sufficiently good to decide the question. With the new one, however, there remains no doubt. Another grating with 17280 lines to the inch, which is temporarily in my possession, shows it nearly, though not quite as well.

The accompanying map of this region of the spectrum gives a good idea of the appearance of things, and the amount of dispersive power obtained. The scale numbers at the top are those of Ångstrom, those at the bottom are Kirchoff's.

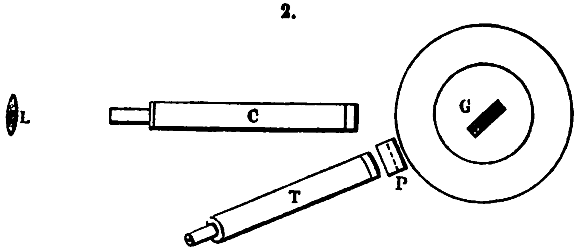
1.

Map of the region of the Corona-line.



The observations are best made in the spectrum of the 8th order (with the coarser grating—in the spectrum of the 5th order with the grating of 17280 lines to the inch) although the duplicity of the line is clearly visible in the spectra of the 6th, 7th, and 9th order, with proper precautions. The arrangement employed is that indicated in fig. 2. C is the collimator, the

2.



beam of light, thrown into the room by a heliostat, being concentrated by the lens L which forms an image of the sun on the

slit. G is the "gitterplatte." P is a prism of 45°, with its refracting edge horizontal, and so placed as to bend upward the pencil of rays from G. T is the observing telescope, with the eye end elevated at an angle of about 35° so as to receive the rays from G after they pass the prism.

The spectra of the higher orders so overlap, that without the prism, or some analogous contrivance, it is impossible to observe in them any but a few of the strongest lines. By the prism these spectra are separated, one lying above the other; the red of the 6th order, for instance, falling below the yellow of the 7th, and this underneath the green of the 8th, while above this green lies the blue of the 9th order, and above that the extreme violet of the 10th. Thus the different spectra no longer interfere, and it is just as easy to observe the spectrum of the 8th order as that of the 1st, except that the former is fainter on account of the greater dispersion, and the obliquity of the grating, which narrows the transmitted pencil. A direct-vision prism in the eye-piece of the telescope answers the same purpose, but less perfectly. The same plan may have been used before. If so, however, I am not aware of it.

Hanover, N. H., April 19, 1876.

ART. LV.—*Contributions from the Sheffield Laboratory of Yale College.* No. XL.—*On a Lithia-bearing variety of Biotite;* by GEORGE W. HAWES.

THE feldspar quarries about Portland and Middletown in Connecticut have furnished many interesting minerals. The quarries are in the large granitic veins which intersect the gneiss and mica schist of the region. These veins, which have been described by various authors, are remarkable for the similarity of their mineral constituents, and the presence in several of rare elements, and it will be shown in this article that a lithia-bearing biotite is generally present. The feldspar is of two kinds, orthoclase and albite; considerable quartz is found, and with the feldspar it often forms beautiful specimens of graphic granite. Tourmaline, beryl, garnet, columbite, muscovite and biotite are common, and other species are found more rarely. Plates of muscovite and biotite united by their edges are of frequent occurrence, and sometimes one forms the center of a large crystal or plate of the other. The cleavage lines which are developed by striking the thin plates with a sharp point show that when the two species are thus united, there is a simple relationship between the axes of the muscovite and biotite, as long since found by Prof. G. Rose to be a general fact in the

case of such combined crystals of mica. Some of the specimens examined by Rose came from granitic veins similar to those of Portland and Middletown. The cleavage lines begun in one mica often run some distance into the other without a change of direction, proving the complete continuity of the two.

The biotite of Portland is black, and possesses a high luster. In thin plates it is transparent, clear, and brown by transmitted light. It is optically uniaxial. Specific gravity 2·96. When heated before the blowpipe it imparts to the flame the characteristic carmine-red color of lithia, and it appears thus to differ from all the described varieties of the species. It afforded me, on analysis, the following results:

	I.	II.	Mean.
Silica	35·59	35·62	35·61
Alumina	19·99	20·08	20·03
Ferric oxide	·15	·11	·13
Ferrous oxide	21·83	21·86	21·85
Manganous oxide	1·19	1·18	1·19
Magnesia	5·26	5·20	5·23
Potash	9·61	9·76	9·69
Soda	·49	·55	·52
Lithia	·96	·94	·93
Titanic acid	1·45	1·47	1·46
Fluorine	·76	·76	·76
Chlorine	*tr.*	*tr.*	*tr.*
Water	1·84	1·90	1·87
	99·12	99·43	99·27

The ratio of the $\mathrm{R} : \overline{\mathrm{R}} : \mathrm{Si}$ is $1 : 1 : 2$; and the analysis hence shows that the mica is an *iron* biotite, which has lithia replacing part of the potash, and which contains much more ferrous oxide and less magnesia than is common. It fuses before the blowpipe to a magnetic globule. Some specimens fuse with greater difficulty and give little color to the flame, indicating a transition toward the more ordinary variety. I would call attention to the fact that the iron of this mica oxidizes with great readiness both when heated and when exposed to the weather, and this shows how easy it would be to derive lepidomelane from it by alteration. This lithia-biotite seems to be widely distributed in granitic veins. Specimens from similar granitic veins in New Hampshire, Massachusetts and North Carolina were examined which imparted more or less of the lithia coloration to the flame, fused to magnetic globules, and which possessed the same physical appearance and the same association as the Portland biotite.

ART. LVI.—*Researches on the Solid Carbon Compounds in Meteorites;* by J. LAWRENCE SMITH, Louisville, Ky.

[Concluded from page 395.]

Action of strong nitric acid on the graphite.—Strong nitric acid, poured upon the powdered graphite that had been treated with ether and bi-sulphide of carbon acted vigorously upon the sulphide of iron mixed with it, and after digestion for some time in the acid and washing thoroughly with water, there remained 55 p. c. of the original matter, which consisted of carbon. This burnt in air with great difficulty, but very easily in oxygen, leaving a residue of one per cent of ash.

The nitric acid solution was analyzed and found to contain

Sulphur	35·05	Troilite.
Iron	62·21	
Cobalt	0·56	
Nickel	0·16	
Magnesia	0·30	
Silica	0·21	
	98·52	

It is a fact of some interest that in the sulphide of iron which occurs in meteoric irons (when these nodules are perfectly free from any adhering iron) the quantity of nickel and cobalt present is very minute, a most singular fact if we are to regard these nodules as the result of segregations from the mass of iron. And still further, while the nickel is very largly the predominant metal of the two in the iron, I have noted that the cobalt predominates over the nickel in the sulphide nodules; but I would not without further examination regard this as likely to be the rule in all cases.

Action of fuming nitric acid mixed with potash chlorate on the meteoric graphite.—The oxidation of graphite by this method is well known to chemists, it having been first pointed out, as I have stated, by Mr. Brodie in 1860, and subsequently by Berthelot in his elaborate memoirs published in the *Annales de Chemie et de Physique*, 4th series, volumes xix and xxx. The result is the formation of a substance which Brodie called graphitic acid and Berthelot graphitic oxide, although the compound invariably contains hydrogen as an essential element in its constitution. M. Berthelot made use of this reaction to study the different forms of carbon, finding that the results of the oxidation varied with the carbon from different sources, only those forms of carbon known as graphites proper furnishing the graphitic oxide. The same chemist studied this oxid-

izing action upon the graphite from the Cranbourne meteoric iron, and also upon the carbon from the Orgueil meteorite, and found that, of the two, only the graphite from the meteoric iron gave rise to the oxide.

The study of this subject I have pushed further, and have oxidized the graphites from the Sevier County and the De Kalb County meteorites, and have also re-examined that of the Cranbourne iron—having been very liberally furnished with a specimen by my friend, Prof. Maskelyne, of the British Museum. The carbonaceous matter from the Orgueil meteorite has also been subjected by me to the same reaction.

The details of conducting the process were identically those proposed by M. Berthelot in the memoirs already referred to, viz: To free the powdered graphite from sulphide of iron by first treating it with strong nitric acid, washing it thoroughly on a filter, drying it and mixing it with five times its weight of potash chlorate, then adding this mixture little by little to sufficient fuming nitric acid to moisten thoroughly the mass. In making the mixture, I place the nitric acid in a capsule and the latter in a little water with a piece of ice, thus avoiding any risk of explosion. The mixture, after standing a few hours is transferred to a ballon d'assais, and gently heated in a water bath at a temperature from 50° to 60° C. for several days. The result of this action upon the graphites of the Sevier County and DeKalb County meteoric irons was the formation of graphitic oxide, with all the characteristics of that furnished to Berthelot by the graphite from the Cranbourne iron, as well as to myself from this last graphite.

The conversion of the meteoric graphite into the oxide is more rapid than that of any terrestrial graphite with which I have experimented. The graphite soon changes from black to green, and finally, after two or three applications of the oxidizing agent, to a perfectly white substance. This, when filtered, washed, and dried under a bell glass with sulphuric acid, gives a yellow powder, somewhat adherent. If the oxidizing action of the nitric acid and potash chlorate be renewed several times on the same material, the oxide gradually diminishes in quantity, and if the process be stopped after the fourth or fifth treatment, the oxide is very gummy, adhering to the filter and preventing complete washing. When dried on the filter it adheres firmly, but can be detached by moistening the filter and rubbing off the paper with the finger, leaving tenacious flaky films.

The reaction and decomposition of the oxide obtained from the Sevier graphite is the same as that of the oxide from other sources.

My experiments on terrestrial graphites have been confined

to the Siberian, Cumberland, and Ceylon varieties; and they show that the graphite under consideration differs from them in being more readily converted into oxide, it requiring only one-fifth to one-third of the time; and if the operation be continued by frequently renewing the oxidizing agents, the oxide first formed gradually diminishes in quantity, being more thoroughly altered, like some of those forms of carbon ranked as not properly graphites.

In fact, it appears that the meteoric graphites, when tested by this process, occupy a place between graphites proper and ordinary carbon, but much nearer to the graphites.

After completing my examination of the carbon nodules of the irons, my aim was to see what general deductions could be made with reference to the relations this graphitic material bore to the carbon found in the black meteoric stones. The material to operate with is, however, very rare; but I had in my collection enough for all necessary comparisons, though needing much more in order to obtain the peculiar products in sufficient quantities for chemical analysis.

The Alais meteorite.

Two grams of this meteorite were pulverized finely and treated with boiling water, which dissolved out a small amount of matter; which substance has been studied by others and it is not my object to recur to here.

The powder was then dried and treated with pure ether, in the same manner as the graphite from the Sevier iron, and the ether allowed to evaporate slowly at a moderate temperature, when the sides of the vessel became covered with acicular crystals, mixed with a few rhomboidal crystals. The residue had a peculiar odor, similar to that of the ether extract from the graphite of the Sevier iron, which odor it nearly lost in the same way, after several days exposure to the air. The form and appearance of the crystals are the same as of those obtained from that graphite; and a portion of the crystals detached and heated in a small tube gave the same character or reaction.

These crystals have already been studied by Prof. Roscoe, of Manchester, as carefully as could be done with the minute quantity at his disposal. My examination is perfectly in accordance with his, and there is no doubt that this product and that from the graphite must be of the same nature.

We must not forget to mention that Prof. Wöhler was the first to call attention to the hydrocarbon in these black meteorites when examining the one which fell at Kaba.

Orgueil meteorite.

This meteorite is one of the most interesting of all the known carbonaceous meteorites. And there are one or

two points connected with it that do not appropriately belong to this paper, of which I will furnish a note before long. Through the liberality of Prof. Daubrée, and the Administration of the Garden of Plants, I have been furnished with the material on which my investigations have been made. This meteorite has, in most respects, been thoroughly examined by M. Cloez, and by M. Pisani, and their results given in the Comptes Rendus for 1864. The former chemist examined the carbonaceous matter as a whole, considering it to resemble humus; and this on drying at 110° gave him: Carbon 63·45, hydrogen 5·98, oxygen 30·75.

I have, as yet, done little toward the re-examination of this substance, which represents from four to six per cent of the entire meteorite, my examinations being made principally for those crystalline products, soluble in ether and bisulphide of carbon, of which I have found about one-half per cent in the meteorite.

The powdered meteorite was first treated with water and heated over a water-bath, and every thing soluble in that menstruum thoroughly washed out. The soluble portion, dried at 100° C., represents 8·65 per cent of the mass. After carefully drying the insoluble portion at 100° C., it was treated with ether in the same manner as the meteoric graphite. The ether was used in large excess, and allowed to remain for ten or twelve hours in contact with the material; the ether was filtered off, and the residue on the filter well washed with ether. The etherial solution was evaporated slowly, when the same acicular crystals made their appearance as in the case of the graphite, and numerous rhomboidal crystals were deposited in the bottom of the beaker. These appeared to be identical with those from the graphite. The action of heat on these crystals is the same as on those from the Sevier graphite.

The powdered meteorite exhausted by the water and ether was next treated by the bisulphide of carbon, when an additional quantity of soluble matter was obtained. On evaporating the bisulphide of carbon, a yellow mass remained having the aspect of sulphur. This, when heated, gave evidence of being sulphur mixed with some carbon compound. And to all appearance it was just like the substance obtained by similar treatment of the meteoric graphite.

The crystals in the upper part of the vessel from which the ether was evaporated being detached by scraping the sides of the vessel with a horn spatula, some bisulphide of carbon was poured upon the portions remaining attached to the vessel by which it was dissolved. The bisulphide of carbon was subsequently evaporated, when a residue was left consisting of a yellow solid surrounded by a dark brown semi-solid mass in

minute quantity. This last is evidently a carbon combination not contaminated with sulphur, while the yellow mass is sulphur containing a small portion of the carbon compound.

I was enabled to obtain over 400 milligrams of these mixtures from about 50 grams of the meteorite, much the larger portion being sulphur. A few attempts were made to separate the sulphur from the carbon compound, but unsuccessfully; and I soon saw that by continuing my efforts, I should exhaust the small supply of material without reaching any useful result. So it was thought better to save what was left of the material as a specimen of it.

The other carbon meteorites I have not yet examined with regard to the points embraced in this report, but I hope to obtain sufficient material before long to allow of this being done, though I do not anticipate any different results from those that have been examined.

The nature of the hydrocarbon found in the meteoric graphite and carbonaceous meteorites.

That this substance belongs to the meteorites at the time of their fall, there can be no doubt; for in the carbonaceous meteorites there is nothing to enable us to account for its formation in the cabinets in which they have been placed after their fall. And in the case of the graphite nodules they were encased in the interior of an iron mass over twenty centimeters in diameter; and, furthermore, the powder operated with was taken from the interior of a compact nodule of graphite.

I have been strongly inclined to consider this as a hydrocarbon containing combined sulphur forming a sulph-hydrocarbon. In the absence of chemical evidence sustaining this view, I lay some stress on the peculiar odor of the ether extract, strengthened by a most singular property of the watery extract from the Orgueil meteorite, of which I will make a short statement, reserving for some future occasion any additional remarks.

If a small quantity of the powdered Orgueil meteorite, say two grams, be treated with water and heated for a short time over a water-bath, no peculiar odor will be observed, however carefully examined. Throw this on a filter and wash with water, then evaporate the filtrate to dryness over a water-bath, and during this time no odor will be observed. Allow the residue to cool, and still there is no odor. But now throw upon the residue a little water, say half to one cubic centimeter, move the capsule around to dissolve the mass, and then on bringing it near to the nose, a marked alliaceous odor will be perceived, sometimes so strong as to be disagreeable, reminding one of the odor of the oil of assafœtida. That it is produced

by a sulphur compound chemists will be apt to admit, perhaps a minute quantity of sulphur compound not unlike the sulphhydrate of ethylene $C^4H^6S^4$; and the needle-shaped crystals may not be far removed from the solid quintisulphide of ethylene, $C^4H^6S^5$, corresponding to sulphur 75·00, carbon 20·00, hydrogen 5·00. The crystals I scraped from the sides of the beaker—at the upper part—on which the ether solution of the Orgueil meteorite was evaporated to dryness, gave—sulphur 79·65, carbon 15·00, hydrogen 3·00.

In the above analysis the amount of sulphur is well determined; but the examination for carbon and hydrogen was made upon so small a quantity, that the results cannot be relied upon as very correct.

Roscoe burnt in dry oxygen ·008 grams of the residue from the Alais meteorite, and obtained ·010 grams of sulphurous acid, ·008 grams of carbonic acid, and ·003 grams of water, making sulphur 125 parts, carbon 54 parts, hydrogen 10.

As the above analysis was made with only eight milligrams, of course the results can be considered only as an approximation; but nevertheless, until we get better they must serve as our only guides.

I have not said anything about the gaseous carbon compounds found in meteorites, as these form a separate study from what is designed in this paper, and besides, Profs. Graham, Mallet, Wright, and others have already investigated their nature. Profs. Wright and Mallet are still engaged in this line of investigation.

Conclusions.

These then are some of the results of my experiments on the carbon of meteorites, and they are of great interest and importance. That we should find in the graphitic concretions from the interior of a solid mass of iron such substances as free sulphur and a hydrocarbon, simple, or combined with sulphur, having a marked odor, was certainly not to be expected, especially as we are almost forced to believe that the iron containing it must have been at some period in a state of fusion.*

The graphite nodules themselves are grand chemical and physical puzzles, as well as all the nodular concretions in meteoric irons; that they have resulted from a process of segregation is self-evident, but how marvelous the completeness of this segregation, for if we analyze the iron even within two or three millimeters of the concretions, only traces of the charac-

* In an article recently published by Dr. Mohr (Annalen der Chem. und Pharm., Dec. 1875, page 257), he advances the theory that meteoric iron and meteoric stones have been formed by the agency of water; his arguments are interesting, but far from being sufficient to cover all the facts in connection with meteorites.

teristic constituents of the nodules are here found. Then again, in the case of the troilite concretions, this sulphide has been separated from the mass of iron, and a phosphide of iron and nickel has been concreting along with it; and yet, there seems to be so great an incompatibility between these two minerals that they could not commingle, but the phosphuret was thrust, as it were, to the exterior of the nodule, there to form a thin covering to the sulphide, like the skin of an orange over the internal pulp.

Again, the graphitic concretions bear no resemblance to the scaly graphite found in the slag of iron furnaces and between the crystals of cast iron, either in structure or appearance; the fractured surface is more like that of the Borrowdale graphite, but the oxidizing action of the nitric acid and potash chlorate on this last differs somewhat from the action on the meteoric graphite. Many and varied have been the hypotheses formed in my mind to account for the formation and accumulation of this graphite, but I must admit that I have been forced at last to abandon them all, as none covers all the facts of the case. In appearance this graphite is more like the amorphous carbon that is separated from cast iron, but the oxidizing action of nitric acid and chlorate of potash at once points out their great difference as shown by Berthelot's experiments.* And although it differs in appearance from the scaly graphite of iron, the oxidation of the two are very similar. I am more inclined to adopt the suggestion of Berthelot, that it may be formed by the reaction of bisulphide of carbon upon incandescent iron, as this reaction is known to give rise to an amorphous graphite analogous to the one under consideration, and its association with sulphide of iron would lend some support to this hypothesis; and still further the presence of free sulphur and a carbon compound, either a hydrocarbon, or sulph-hydrocarbon, points also in that direction for a solution.

It is very clear from the present accumulated knowledge of the geological occurrences of graphite that we must abandon all attempt to account for its formation by any one series of reactions on the interior of our globe; for it is to be found in basaltic rocks, in the older crystalline rocks, and through all the series of rocks up to the recent Tertiary formations; and when we add to this the laboratory experiments of Berthelot that I have so frequently quoted, this view of the subject is strengthened. But on this point I may have something more to say in a paper on the Ovifak iron, and the graphite in the basalt in which this iron is found.

The carbon from the black meteorites, as the Orgueil, Alais, etc., I consider as having a similar origin to that found in the

* Annales de Chem. et de Physique, Fourth Series, xix, 425.

irons; for I have proved that they both contain similar crystalline products soluble in ether and sulphide of carbon, and while the carbonaceous matter reacts differently when treated with nitric acid and potash chlorate, this may arise from the difference of conditions under which the reaction took place that gave rise to it.

That the carbonaceous matter in the black meteorites is to be regarded as a kind of humus arising from organized matter is contrary to all we know about humus. For if we examine the mineral constituents of these meteorites, we find them to be a granular mass, with particles more or less impalpable, composed essentially of olivine and pyroxene, a most unpromising soil for so luxuriant a growth of vegetation as must have occurred to produce so abundant a percentage of carbonaceous matter as that found in the Orgueil meteorite. The action of caustic potash upon it is different from the action of that alkali upon what is commonly called humus; (although we must bear in mind that humus is not a well-defined substance; it being commonly regarded as vegetable matter that has not undergone complete decomposition into water and carbon, but by imperfect oxidation was converted into a varied mixture of carbon and certain organic compounds rich in carbon, some of them soluble in caustic alkalies). After the powdered Orgueil meteorite has been exhausted by water, ether, and sulphide of carbon, caustic potash or soda dissolves but an exceedingly minute trace of the carbonaceous matter, and even that trace may be a little hydrocarbon not extracted from the mass by the ether and sulphide of carbon. If a portion of the same be dried at 110° C., and then heated in a closed tube, water will not be given off until the temperature is elevated considerably. If the temperature be further increased, only a very slight odor is apparent; and this is another marked difference between it and humus. If heated on platinum foil, the carbonaceous matter burns off very readily with little or no odor, leaving an abundant residue. According to my experiments this combustible matter amounts to about 4·5 per cent of the entire meteorite.

It is not at all improbable that the carbonaceous matter of the black meteorites approaches in character the so-called hydrated carbon first pointed out by M. Eggert, but so clearly defined by MM. Schutzenberger and Bourgeois in a communication made to the Chemical Society of Paris in April, 1875, which was obtained from white cast iron by dissolving away the iron. But it is a question in my mind whether the carbon combination thus obtained from white iron is to be properly considered a hydrated carbon; that is to say, whether we are to consider the H^2O as united to the carbon in the same way as it is to metallic oxides to form what are known as hydrated

oxides. If, however, it is to be considered as combined in a manner analogous to the H^2O, with ethyl to form alcohol, then there may be some plausibility in the hypothesis. For it will be remarked in referring to the actions of this hydrated carbon that it in no way resembles amorphous or ordinary carbon.

It is represented by MM. Schutzenberger and Bourgeois as follows: $C^{11}:3H^2O$=carbon 70·95, hydrogen 3·23, oxygen 25·80 per cent.

According to M. Cloez, the carbonaceous matter of the Orgueil meteorite, after being dried at 110°, was found to be composed of carbon 63·45, hydrogen 5·98, oxygen 30·75; and when we consider that some of this hydrogen belongs to the hydrocarbon now known to exist in that meteorite, the remainder of the hydrogen will approach near the proportion required to form water with the oxygen; and the quantity of carbon that may exist as a hydrate will be slightly diminished.

Attempts were made to separate completely all the mineral matter from the carbon, but I have failed to do so, after using fluorhydric acid alone, and in conjunction with nitric acid, also fluoride of sodium and sulphuric acid with a small amount of water, then treating the residue with cold nitric acid. There is no difficulty in getting rid of a great part of it, but in every instance the carbonaceous matter has been altered, however carefully the temperature was managed.

When this matter thus obtained is heated in a closed tube, after being dried at 110° C., it not only furnishes water at about 250° C., but gives out a very strong odor somewhat like that produced from certain bituminous coals, at one point resembling the disagreeable odor of an ignited cigar of a very inferior quality of tobacco.*

Viewed in the light of these experimental researches, the most reasonable conclusion is that this carbonaceous matter is not in any proper sense either carbon or humus, but a carbon compound analogous to the one just referred to.

Future researches upon these solid compounds, resembling in appearance amorphous carbon, such as hydrographitic oxide, pyrographitic oxide, carbon-hydrate, and similar compounds that may yet be discovered, will doubtless throw some light on the true nature of the carbonaceous compound of the black meteorites. So far as our knowledge now extends, its formation and its origin are wrapped in as much obscurity as the origin of the bodies in which it is found.

What we do know is that this carbonaceous matter occurs with the same minerals, viz., olivine and pyroxene, which are the predominating constituent materials of all stony meteorites;

* This odor will be found to belong to the hydrated carbon from cast iron, when heated in the same way.

also with the nickeliferous iron found in both the stoney and metallic meteorites; and furthermore, that this carbonaceous matter contains curious crystalline products soluble in ether and sulphide of carbon, which last have been traced in the graphite nodules in the interior of the metallic meteorites. Moreover in these graphite nodules we have found magnesia, which is so uniformly a constituent of the minerals of the stoney meteorites.

So far then as our present knowledge goes, we know of celestial carbon in three conditions, viz: in the *gaseous form* as detected by the spectroscope in the attenuated matter of comets; in meteorites in the *solid form*, impalpable in its nature and diffused in small quantities through pulverulent masses of mineral matter that come to the earth from celestial regions; also in the *solid form, but compact and hard*, resembling terrestrial graphite, and this is imbedded in metallic matter that comes from regions in space. But while we speak of these as forms of carbon, I think we should be careful in associating it in our minds with the element carbon as we understand it in its pure state whether crystallized or amorphous, for I cannot reconcile the carbon vapor detected in comets as simply that known as pure carbon in the form of an elastic vapor, nor are we to circumscribe ourselves with the notion that this cosmical carbon has an organic origin.

The researches embraced in this communication, while in many respects of a novel character, are imperfect from their very nature, both from lack of material for a thorough and complete study, as well as from the present imperfect methods of operating upon a minute quantity of the most interesting of the substances obtained.

I have therefore detailed as carefully as I could all the results as they have developed themselves, hoping that future opportunities may be afforded for continuing them, when new celestial messengers of the carbonaceous type shall visit our globe.

ART. LVII.—*Results of Experiments on Contact Resistance;* by Professor W. A. NORTON.

[Read before the National Academy of Sciences, April 21, 1876.]

THE experiments here referred to were undertaken with the view of determining the law of the diminution of the minute distance between two surfaces in contact, with the increase of the contact pressure; and its dependence on the extent, condition and nature of the surfaces in contact. Rectangular pieces of various substances $\frac{1}{8}$ inch in thickness, $\frac{1}{4}$ inch in width, and of

suitable length for clamping were used in the experiments. The lower piece was clamped to a horizontal iron bar, which was firmly clamped to the vertical pillars of the testing machine used in my former experiments on deflection and set, and was also firmly propped directly beneath the point where the contact occurred. The other piece, $\frac{3}{4}$ inch in length, was keyed to the under surface of the lever used in the same experiments, at the farther end. The weights were placed on a scale pan resting above this on the lever, and vertically over the surfaces in contact. The depressions of this end of the lever were determined by means of a micrometer screw, which gave the equal elevations of the other end to within $\frac{1}{40000}$ of an inch. The firmness of the lower contact piece and its support was frequently tested by causing the weights to press directly upon it, without the intervention of the lever. The small thermal error of the apparatus was carefully determined and allowed for whenever any perceptible change of temperature occurred during any single series of experiments; but the precaution was taken to secure a nearly uniform temperature during the progress of the experiments. The weights employed, in the more precise determinations, ranged from 2 ounces to 24 ounces. The apparent surface of contact varied from $\frac{1}{32}$ of a square inch to a mere point. The touching surfaces were in some instances smooth, in others rough; and in the contact of plate glass with plate glass, highly polished. The decrement of contact distance was noted whenever a weight was put on, and the increment when the weight was removed, and in general the average of the two taken. By this means the thermal error, when the rise or fall of temperature was uniform, would be eliminated; as well as any error that might result from a change in the coefficient of the contact resistance, induced by the pressure and not passing off when the weight was removed. That errors from irregular variations of temperature, irregular variations of the coefficient of molecular resistance, and accidental causes, might be in a great degree eliminated, the mean of a considerable number of separate determinations was obtained in each case. A comparison of these means for sets of experiments differing in number, showed that the irregular and accidental errors were generally small. The initial pressure was the same in the different sets of experiments, and was very slight—being barely sufficient to secure a decided contact.

When a weight was applied the resulting diminution of the contact distance was generally greater than the increase that resulted from the removal of the weight. The reverse very rarely occurred; though the increment was sometimes equal to the decrement. It therefore generally happened that there was a slight contact set when the pressure was withdrawn. These

facts show that the application of the contact pressure was generally attended with a diminution of the coefficient of molecular resistance at the surface of contact. When the pressures were renewed at short intervals, the contact set at first observed was generally maintained, and often increased.

The following table gives the diminutions of the contact distance obtained with the several weights, 2 oz., 4 oz.., 8 oz., 16 oz., and 24 oz. It is to be understood that the numerical determinations given in the table are the means of a number of individual determinations. It thus happens that the decimals are carried beyond the reliable reading of the apparatus. The mean results of different sets of experiments are given in two instances. The apparent surface of contact was about $\frac{1}{32}$ of a square inch, except in the case of the contact of a flat surface with a round surface of sharp curvature, in which the area of contact was too minute to be estimated.

	Iron on Iron.	Same.	Average.	Iron on iron,	Same.	Average.
	Surf. smooth.	Same.		Flat surface on round surf.	Same.	
	In.	In.	In.	In.	In.	In.
2 oz.	0·000170	0·000162	0·000166	0·000165	0·000162	0·000163
4 "	·000250	·000285	·000267	·000240	·000275	·000257
8 "	·000340	·000325	·000332	·000320	·000275	·000297
16 "	·000450	·000425	·000437	·000410	·000425	·000417
24 "		·000500	·000500			

	Iron on brass.	Brass on brass.	Brass on brass.	Plate glass on plate glass.	Gen'l average	Reliable average.
	Surf. smooth.	Surf. smooth.	Surf. rough.	Surf. polished		
	In.	In.	In.	In.	In.	In.
2 oz.	0·000167	0·000170	0·000175	0·000170	0·000169	0·00017
4 "	·000256	·000250	·000267	·000212	·000251	0·00025
8 "	·000335	·000256	·000250	·000294	·000294	0·00029
16 "	·000412	·000410	·000400	·000350	·000404	0·00040
24 "	·000500	·000500	·000500	·000475	·000493	0·00049

On examining this table it will be seen,

(1.) That the diminutions of contact distance were very nearly the same, whatever was the nature, or condition of the surfaces in contact.

(2.) That they were nearly independent of the extent of the surface in contact; since they were nearly the same when the surfaces touched in a mere point, as when the surface of contact had an extent of one-fourth of an inch by one-eighth of an inch.

(3.) That the diminution of contact distance for an increase of one ounce in the pressure, was nearly inversely proportional

to the pressure. The fractions of an inch that would answer to this law are as follows: For 2 oz. 0·00017 in., for 4 oz. 0·00025 in., for 8 oz. 0·00033 in., for 16 oz. 0·00041 in., for 24 oz. 0·00046 in. These values differ but little from those given in the table as the reliable averages. The only material discrepancies occur in the results for 8 oz. and 24 oz. Now the table of results shows that in a few cases some cause was in operation to reduce the diminution of contact distance for 8 oz. to nearly the value observed for 5 oz. The same tendency was also often manifest in the individual experiments. If we reject the results for 8 oz. in these cases, that occur in the table, the average diminution of contact distance for a pressure of 8 oz., comes out 0·00032 in., and the discrepancy is reduced to 0·00001 in. Again the experimental result for the case of 24 oz. is 0·00003 in. larger than the law above stated calls for; but the individual micrometer readings were liable to this amount of error, and hence if the support had been depressed by this amount, by the 24 oz. weight, it would have escaped detection.

That the law of diminution of the contact distance which has been stated is very nearly, if not the exact law of Nature in the case, may also be inferred from the fact already stated, that the variation of contact distance is nearly if not entirely independent of the extent of the surface of contact. For if the contact area be diminished in any ratio, say 2 to 1, under the pressure of the same weight the pressure at each individual point of contact would be doubled, and the increment of pressure at each point, resulting from an additional weight of one ounce, would also be doubled. Now if we suppose the law, just referred to, to hold good for a given surface of contact, the diminution of contact distance at each point should be inversely proportional to the pressure on it, and therefore be half as great for the same increment of pressure there, as in the case of the larger area of contact; but in fact the additional pressure at a single point, resulting from an additional weight of one ounce, is doubled, and hence the diminution of distance should be the same as in the case of the larger area of contact.

We may conclude, therefore, that in the contact of surfaces, the force of molecular repulsion, in which the force of contact resistance consists, conforms in its variations very nearly, if not exactly, to the law that the decrement of the distance between the molecules, for the same small increment of pressure, is inversely proportional to the effective pressure by which the molecules are urged into closer proximity. If then we suppose the distance between the molecules to be denoted by x, and the effective molecular repulsion by r, and observe that x is a decreasing function of r, we may put $dx = -m\frac{dr}{r}$. This gives,

by integration, $x=c-m \log r$; or $x=m \log \frac{n}{r}$, in which n is a new constant. It appears then that the curve of the effective molecular repulsion, which resists contact pressure, is the logarithmic curve.

This force of molecular contact repulsion cannot be identical with the effective repulsion in operation in the interior of bodies, when they suffer compression; for the same force of pressure produces a vastly greater diminution of molecular distance at the surface of contact than in the interior of bodies. Thus, in our experiments, a pressure equivalent to 30 lbs. to the square inch, diminished the contact distance by $\frac{1}{3300}$ of an inch. This pressure operating on an iron rod one inch in length would compress it $\frac{1}{1000000}$ of an inch. The distance between its individual molecules would be reduced $\frac{1}{1000000}$ part. This is immeasurably smaller than the observed diminution of contact distance; and therefore than the diminution of molecular distance at the point of contact, if the decrease of contact distance consisted simply in the closer approximation of the contiguous molecules of the two surfaces. It is not improbable, however, that it consists in part in a compression of a thin layer of molecules at the surface, having a comparatively small coefficient of elasticity. If such a layer have a thickness as great as $\frac{1}{100}$ of an inch, the compression it would receive from a pressure of 30 lbs. to the square inch, would still be 32000 times greater than a layer of the same thickness in the interior of a mass of iron would experience from the same pressure.

We must conclude, therefore, that the force of molecular contact repulsion has, for the same diminution of the distance between the molecules, an exceedingly feeble intensity in comparison with that of the internal molecular repulsion. It must operate then at greater molecular distances; and accordingly the range of its action must lie outside of that of the attraction of cohesion. In confirmation of this conclusion it may be stated that in none of the experiments was any evidence obtained of an attraction between the surfaces, operating outside of the contact distance.

It would seem, then, that the experiments discussed have served to establish the existence of an effective force of molecular repulsion, in operation at the surface of contact of bodies, whose sphere of action is external to the range of the attraction of cohesion for the same molecule, and which has a much feebler coefficient of intensity than the effective molecular repulsion exerted within the sphere of this attraction. They have also made known the law of variation of this force with the change of molecular distance, and shown that its coefficient of intensity is the same, or nearly the same, for the different substances used in the experiments.

ART. LVIII.—*On some Physical Observations of the Planet Saturn*; by L. TROUVELOT.*

DURING the last four years I have had many occasions to observe the planet Saturn, and to study its physical constitution under very favorable circumstances. My series of observations extends over more than a hundred nights, many of which were as good as could possibly be desired, both for the steadiness of the image, and for the amount of light.

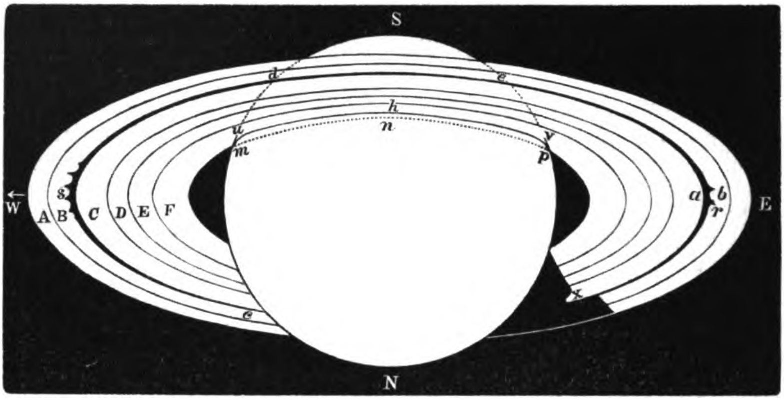
The observations on which this communication is based were made: 1. With the fifteen-inch refractor of the Harvard College Observatory, while I was employed by Professor Winlock in making the sketches for the series of the astronomical engravings published by him. By his kind permission I have availed myself of considerable of the data thus obtained. 2. With the twenty-six inch refractor of the Washington Observatory while it was still in the hands of Messrs. Alvan Clark & Sons. 3. With the six-and-one-quarter-inch refractor of my own Physical Observatory at Cambridge. During the past summer, I was honored with an invitation from Admiral C. H. Davis, Superintendent of the Naval Observatory, to visit Washington and make some sketches with the magnificent instrument of this establishment. I thus had an excellent opportunity to confirm all my previous observations. The powers used ranged, according to the amount of light and the steadiness of the atmosphere, from 140 to 700. On good nights, however, higher powers have been tried, but never with advantage, as the light lost by the use of high powers is generally of more importance for good vision than a superior enlargement with a reduced amount of light.

Numerous observers, among whom are such eminent astronomers as Sir William and Sir John Herschel, Otto Struve, Dawes, Bond, etc., have made careful studies of this planet; and it is not, therefore, to be expected that very important discoveries remain to be made by later observers. As I have had the opportunity of observing with the same instrument many of the celestial objects previously studied with so much success by Professor George P. Bond, it gives me the greatest pleasure to express my admiration for the accuracy and fidelity of his observations.

The following diagram, representing the outlines of Saturn and its rings, will facilitate my explanations, and give clearness to the subject:—

* Read before the Amer. Acad. of Arts and Sciences by William A. Rogers, Dec. 14, 1875.

1.

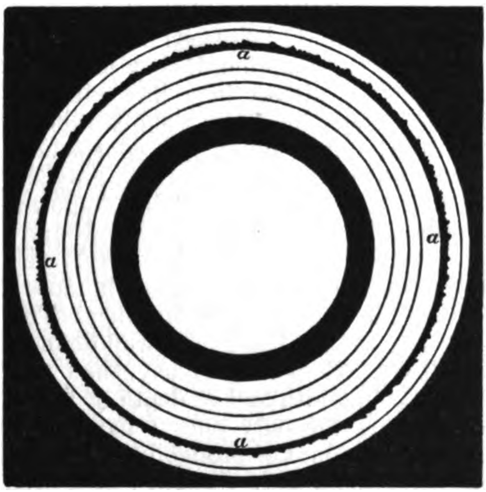


When looking at the rings, attention is at once attracted to a conspicuous dark line, apparently concentric with the outer margin of the rings, and boldly surrounding the planet, and adorning it by its sharp contrast. This dark line is known as "the principal division of the rings," and is shown at *a*, fig. 1. Owing to the effect of perspective, it always appears widest at the two extremities of its major axis, on that portion called "the ansæ," as there only, it is seen without foreshortening. I have carefully compared the intensity of this dark line with the sky outside of the rings, and inside of the ansæ; and I have always found it to be slightly lighter. All my observations also agree in showing this line as appearing a little narrower on the side farther from the observer, at *c*, fig. 1, than it appears on the opposite side, at *d*. This phenomenon could readily be explained by supposing that the outside margin of the ring *C* is on a plane higher than the ring *B*, and may, consequently, conceal a narrow portion of the dark line. The assumption of such an hypothesis seems to be fully supported by the observations, as will be shown hereafter. It is furthermore to be remarked, that the outside margin of the ring *C* has always appeared to me to be more sharply defined on that part of the ellipse farther from the observer than on the side nearest. The case is the same for the outer border of the ring *A*, which appears sharper on its northern than on its southern side. In both cases, the northern portion of the ellipse is limited by the matter composing the surface of the rings on their flat and illuminated side; while for the southern portion it is seen a little edgeways, and this may account for the vagueness of its outlines on this side.

Soon after the beginning of my observations, in October, 1872, my attention was called to a singular appearance not heretofore noticed, as far as I am aware. Two small, dark, angular forms,

r, fig. 1, were seen near the summit of the principal division of the rings on the following side, and apparently projected upon the ring *B*. After an interval of three hours, no sensible change could be detected in the position of these forms; and on the following day they were seen occupying about the same position. This phenomenon could easily be explained by supposing there were some sort of protuberances on the external edge of the ring *C*, casting their shadow under the oblique rays of the sun, which occupied then a proper position to answer to this hypothesis. But some days later, another of these singular forms was observed 180° from the first, on the preceding side, at *s*. This at once overthrew the supposition that they were shadows cast by protuberances existing on the ring *C*; since in this case the shadows would have been projected opposite the sun on the ring *C*, and not on the ring *B*. Since that time, I have rarely observed the planet without seeing some of these singular appear-

2.



ances, either on one side or the other, but generally on both sides. The number of these dark forms is variable. One, two, three, four, and even five, have been seen at the same moment, and on the same side. Though these forms are variable, and appear and disappear, I have never been able to detect in one night any change of position which could be ascribed to the rotation of the rings.

The most plausible explanation of the phenomenon which I can conceive is, that the inner margin of the ring *B*, which forms the outer limit of the principal division, is irregular, jagged, and deeply indented, as shown at *a*, fig. 2, which represents Saturn as it would appear to an observer placed above one of its poles.

As Bond speaks of the principal division of the rings as "not being perfectly elliptical," and as in one instance he has suspected that it "was narrower in some places," it is to be inferred that he had some faint glimpses of the phenomenon which I have observed, and which possibly may be more conspicuous now than twenty years ago.

But the fact that this phenomenon has not been observed earlier does not necessarily prove that it had no existence before; as it is well known, by those who have had experience with the telescope, that one may look for a long while at a celestial object, and miss perceiving what he will readily see when once he is told where to look, and what to look for. Seeing what is new and unsuspected is quite different from seeing what has been observed before.

Though no noticeable changes in the position of the dark angular forms could be observed in the course of two or three hours, it does not follow that the system of rings does not rotate upon an axis, as theory indicates; since the supposed indentations seen on the ansæ would be placed in the most unfavorable positions for showing their motion, if they have any, because it would be accomplished almost in a line with the visual ray, either approaching or receding from the observer.

Next to this division, but much less conspicuous, and to be seen only on very good nights, is a narrow, grayish, and somewhat diffused line, called "the pencil line," shown at *b*, fig. 1. I have never been able to trace this line all around the planet, as it diminishes very rapidly with the foreshortening, and is soon lost. Probably I have never traced it more than 30° or 40° on each side of the major axis of the rings. The pencil line has never appeared to me black and well defined, but rather grayish and diffused. Sometimes I have had the impression that it was irregular in width and in depth of tint.

These two lines are the only ones I have observed, which could, with a certain amount of probability, be said to be a separation of the rings; though they might just as well be depressions, or dark belts, especially the outer one. But the fact that they have been observed on both surfaces north and south, apparently corresponding in position, is in favor of their being real separations of the rings. Though I have repeatedly endeavored to see the planet through the principal division between *d* and *e*, fig. 1, I have never seen the faintest traces of it; and I am not aware that others have been more successful.

If the principal division of the rings is, in fact, what it is said to be,—viz: a space free from matter, and entirely disconnecting the rings *B* and *C*,—I do not see why the planet has never been seen through it. If the planet could be seen through that space, the dark line forming the principal division would be in-

visible from d to e, as the bright light of the planet would shine through in its place, and be undistinguishable from that of the rings. It may be objected that the invisibility of the planet through the principal division is due to the thickness of the ring C; but in this case, why should the black sky be seen, if the planet is invisible?

Besides the two dark gaps or divisions of which I have just spoken, the rings are subdivided by concentric zones or belts, which reflect light of different hues and intensity. Though only three of these belts are conspicuous, I have found by careful examination that there are six which I can always recognize whenever the illumination is good, and the image steady. These zones are represented on the diagram, fig. 1, at A, B, C, D, E, F. On several occasions, I have had a pretty distinct impression of seeing the whole surface, from C to E inclusive, grooved, as it were, by numerous narrow concentric belts. These impressions may have been illusory, as they were almost instantaneous; but I have since learned by experience, that, after all, rapid impressions are not so much to be discarded, as, quite often, even more fugitive impressions have proved in the end to be real. A striking instance in my own experience may be worth recording. This summer I made a study of the Horseshoe Nebula in Sagittarius with my 6¼-inch refractor. During the course of my observations, I was much annoyed by what appeared to me as faint ghost-like reticulated shadows projected upon the nebula. I at first thought I had left the reticule of squares ruled on glass in the eye-piece; but having convinced myself that this was not so, and the same appearance again presenting itself, I wiped my eye, but with no better result. As I experienced the same thing on other nights, I paid no more attention to it, thinking the trouble was in my sight. Some time afterwards, while in Washington, I had an opportunity of studying the same nebula with the great twenty-six inch refractor of the Naval Observatory. I was not a little surprised to see that the ghost-like reticule which I wanted so much to rub out of my eye while at home, was caused by dark channels in the nebula itself, which is divided on the preceding side by bright luminous patches, separated by dark intervals.

In order of brightness, the zones or belts composing the system of rings run as follows: C, D, B, E, A, F; C being by far the brightest, and F by far the darkest. The zones A and B have a bluish cast, or light slate color; C is of a bright luminous white; D is slightly grayish; E is a little darker; while F, which is very dark, is tinged with bluish purple.

A is separated from B by the pencil line; B from C by the principal division; while the others do not show any separation whatever, and are only limited by the contrast of their different

colors and shades, and seem to be in immediate contact. However, the different zones do not terminate abruptly where they come in contact, but seem somewhat blended into each other. This is especially the case between *E* and *F*. Though at that point the contrast between the two internal rings is very great, yet it is impossible to see any line of division, so much do they mingle at their point of contact.

On good nights, I have often observed on that part of the rings *A*, *B*, and *C*, seen on the ansæ, an unmistakable mottled or cloudy appearance such as is represented on Plate 1. This appearance was always more characteristic and better seen on the ring *C*, especially near its outer margin, close to the principal division. It would seem, as has been already remarked, that the ring *C* is on a higher level than that of the rest of the rings, and that the cloudy appearances observed there form by their accumulation some kind of protuberances of different heights and breadths. The bright spots resembling satellites, so often observed by Bond in 1848, when the plane of the rings was parallel with that of the ecliptic, were probably caused by the crests of some protuberances similar to those now seen on the ansæ. The form of the shadow thrown by the planet on the rings on Nov. 30, 1874, as shown at x, fig. 1, seems also to agree with this hypothesis. The curious and deep indentation of the shadow at x, in that part where it it is projected on the outer border of the ring *C*, is perfectly explained on the supposition that this part of the ring is on a higher level. The same shadow, as it appeared projected on the rings *B* and *A*, also clearly indicates that the plane of these zones is on a lower level.

In order to find the shape of the surface of the rings from the observation of the form of the shadow thrown by the planet, I have experimented on a miniature representation of Saturn, illuminated by a lamp occupying the position of the sun, while my eye occupied the position of the earth. By successive trials in altering the shape of the miniature rings, I have soon found what must be the form of the rings in order to give to the shadow the same appearance which had been observed on the planet; and the result agrees with the explanation already given.

From the form of the shadow as it has appeared at different times during the last four years, and from the experiment just mentioned, it seems pretty clear to me, that, from the inner margin of the dusky ring *F*, the thickness gradually increases until it reaches the extreme border of the ring *C*, where it gently decreases, as indicated by the rounding of the shadow at this point; after which it sinks perpendicularly down, until it comes even with the general level of the rings *B* and *A*. The slightly curved appearance of the shadow of the planet during the present year, with its concavity turned towards its globe, also supports this hypothesis.

Though in general, the level of the ring *C* is always higher than that of the rest of the system, it does not seem, however, to be uniform and permanent, but varies, either by the rotation of the rings upon an axis, or by some local changes in the cloud-forms themselves; as in several instances I have observed quite rapid and striking changes taking place during the course of one evening in the indentation of the shadow shown at *x*, fig. 1. Sometimes the indentation appeared to increase, indicating a higher level; and sometimes to decrease, indicating a lower level.

That the thickness of the rings is increasing from the interior margin of the dusky ring to the outer border of the bright ring *C*, seems to be corroborated by the phenomena which I have observed on the dusky ring, and of which I shall speak presently.

On all favorable occasions, I have made careful searches on the dusky ring for the divisions suspected by Bond; but I have never had the faintest glimpses of them. The dusky ring appears to me to be continuous, though it is certainly not of the same thickness throughout. Whatever may be the material of which this ring is composed, it is quite rarefied; and it becomes more and more so as it approaches its inner margin. There, it seems to be composed of discrete particles, each of which reflects the light separately; and by applying high powers to telescopes of large aperture, I have had the impression that the supposed particles were more widely separated by the increase of magnifying power. I do not pretend to have seen distinct and isolated particles in the dusky ring; but by instants my impressions have been so decided, that it seemed as if only a little more favorable conditions were required to enable me to see separate corpuscles of matter. The appearance was somewhat like fine particles of dust floating in a ray of light traversing a dark chamber.

The inner border of the dusky ring, notwithstanding its dark appearance, is sharply defined on the dark sky within the ansæ; but it loses this sharpness of outline in that part which is seen projected upon the disk of the planet. There it appears very diffused and ill-defined.

The inner border of the dusky ring, as seen within the ansæ, forms a part of a perfect ellipse concentric with the other rings; but these graceful curves are remarkably and quite abruptly distorted where they enter upon the disk of the planet at *m* and *p*, fig. 1. At these points, they are seen turning up rapidly, describing a short curve; after which they continue parallel with the curves of the other rings until they meet at *h*. If the ellipse described within the ansæ should cross the planet without any deflection, it would be seen along the dotted line, fig.

1, and pass through *n*: while, on the contrary, it is seen above at *h*.

I was surprised, at first, by this singular phenomenon; but I at last satisfied myself with the following explanation: If we conceive the dusky ring to be made up either of vapors or of numerous small independent solid bodies, and, moreover, if we conceive the thickness of this ring as increasing from its interior margin to its outer limit, we shall have an easy explanation of the observed phenomena. When the matter composing this ring, whether solid or gaseous, is seen projected upon the disk of the planet brilliantly illuminated, it will be lost, and will individually disappear, absorbed by the irradiation of the bright light surrounding it, and it will remain visible only at that part where it forms a stratum thick enough to overpower the effect of irradiation.

The fact that the distortion of the inner margin of the dusky ring is not abrupt at *m* and *p*, where it enters upon the disk, but is gradual, seems to prove that the planet is less luminous on its border than elsewhere, providing the above explanation holds good; and this may be owing to the absorption caused by an atmosphere surrounding the planet.

Bond has represented the limb of the globe of Saturn as seen through the whole width of the dusky-ring. In this he agrees with all previous observers. All the drawings of Saturn represent the limb of this planet as plainly and equally visible throughout the dusky ring, becoming invisible only where it enters under the internal margin of the ring *E*. In Bond's memoir, it is positively stated that Mr. Tuttle saw the limb of the planet through the whole width of the dusky ring. If these observations are correct,—as without doubt they are,—the solid particles, vapors or gases, composing this ring, must have undergone some changes of position since Bond's time; as by using the same instrument, and even one of almost double the aperture, I have not been able to confirm these observations.

During the last four years, I have never been able to see the limb of the planet Saturn under the dusky ring, beyond the middle of its width. As it enters under it at *m* and *p*, it remains quite distinct for a short distance; but, as it advances farther in, it diminishes gradually; and it entirely vanishes at about the middle, at *u* and *v*; as if the matter composing the dusky ring was more dense or thicker towards its outer border. This observation has been so carefully made, and so many times repeated, the phenomenon has been so distinctly seen, that there is not the least doubt in my mind as to its reality. Therefore it seems pretty certain that changes have lately taken place in the distribution of the matter composing the dusky ring.

As already shown, the substance composing the dusky ring

does not seem to be uniformly distributed; but seems moreover to be agglomerated here and there into denser masses, which I have often recognized upon that part of the dusky ring crossing the planet between *u* and *v*. These supposed agglomerations appeared as dark masses, intercepting the light of the planet. This phenomenon could not be attributed to dark markings on the planet, seen through the dusky ring; since there are no markings so dark and so small on Saturn. Neither could they be produced by the dark bands sometimes surrounding the globe of Saturn, as some traces would have been detected on the edge of the dusky ring, since these bands are usually wider than the transparent part of the dusky ring.

Of the planet itself I have little to say. It has certainly a mottled or cloudy appearance, like Jupiter. The clouds of Saturn are more finely divided, like certain forms of the cirri clouds of our own atmosphere. The cloudy appearance of Saturn, of course, is not so easily seen as that of Jupiter. It always requires a good steady night to see it.

I have never seen the planet striped with a large number of parallel bands, such as some observers have described. Three or four form the extreme limit. Nor have I seen the bands so conspicuously marked, so regular, so distinct in outline, and so dark; the equatorial band being always by far the most conspicuous, while the others were barely perceptible. The equatorial belt has always appeared to me to be slightly tinged with a delicate carmine red, very much like the equatorial belt of Jupiter; only the pink color of the former is much fainter. In no instance could I compare the color of this band to "brick red," as it is commonly described.

Like the equatorial belt of Jupiter, that of Saturn is variable in width, and changes its form as well as its position. It is usually composed of two grayish, irregular bands, forming its limits north and south, between which are seen flocculent pinkish cloud-forms.

The general color of the planet differs from that of the rings, in being of a slight warm brown in which there is a yellowish tinge. The contrast of color with the rings is better seen by the use of very high powers.

To conclude: my observations show,—

I. That the inner margin of the ring *B*, limiting the outer border of the principal division has shown on the ansæ some singular dark angular forms; which may be attributed to an irregular and jagged conformation of the inner border of the ring *B*, either permanent or temporary.

II. That the surface of the rings *A*, *B*, and *C*, has shown a mottled or cloudy appearance on the ansæ during the last four years.

III. That the thickness of the system of rings is increasing from the inner margin of the dusky ring to the outer border of the ring *C*, as proved by the form of the shadow of the planet thrown upon the rings.

IV. That the cloud-forms seen near the outer border of the ring *C* attain different heights, and change their relative position, either by the rotation of the rings upon an axis, or by some local cause; as indicated by the rapid changes in the indentation of the shadow of the planet.

V. That the inner portion of the dusky ring disappears in the light of the planet at that part which is projected upon its disk.

VI. That the planet is less luminous near its limb than in the more central parts, the light diminishing gradually in approaching the border.

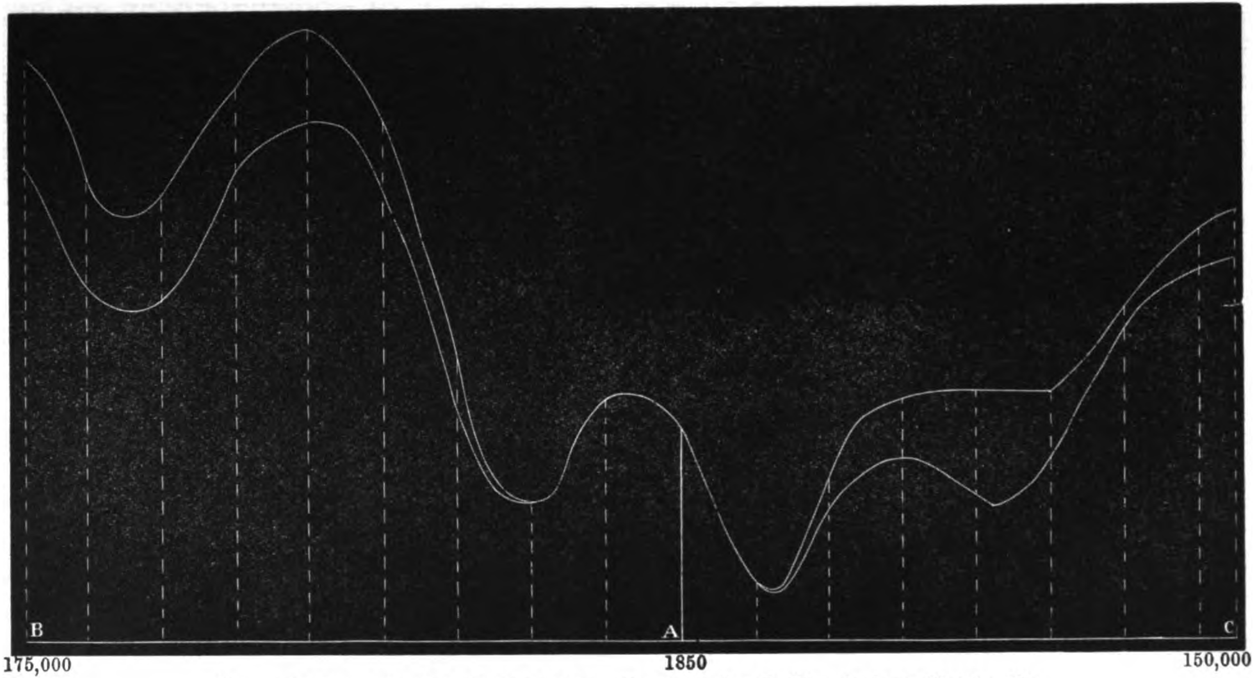
VII. That the dusky ring is not transparent throughout, contrary to all the observations made hitherto; and that it grows more dense as it recedes from the planet; so that, at about the middle of its width, the limb of the planet ceases entirely to be seen through it.

VIII. And, finally, that the matter composing the dusky ring is agglomerated here and there into small masses, which almost totally prevent the light of the planet from reaching the eye of the observer.

Cambridge, Dec. 1, 1875.

ART. LIX.—*Curve of Eccentricity of the Earth's orbit;* R. W. McFARLAND.

THE diagram on the following page gives the curve of eccentricity as found in Croll's work, and also in Stockwell's. The former was computed with a view of explaining the climate of past time; the latter, in examining the moon's mean motion. It will be seen that the curves have the same general form, differing in the value of the ordinates, more than in the position of the maximum and minimum points. I have recomputed the values by Le Verrier's old formulæ, and find Croll's figures correct in most cases, and not in error to the amount of ·001 except in one instance. My work extends over 1,100,000 years, and is for points nearer together than Croll's. Stockwell's is doubtless nearer correct than the other, but there is substantial agreement. The two curves for the last 40,000 years, and for the next 30,000, are almost identical; so nearly is this the case, that only one line is drawn in the figure for those periods.



Curve of eccentricity of the Earth's Orbit. The upper line Croll's; the lower, Stockwell's.

The following table gives the difference between perihelion and aphelion, the sun's mean distance being 92,000,000 miles.

Before 1850. years.	Croll. miles.	Stockwell. miles.
175,000	8,400,000	6,750,000
160,000	6,700,000	5,150,000
140,000	6,360,000	4,910,000
120,000	7,920,000	6,590,000
100,000	8,700,000	7,400,000
80,000	7,320,000	6,290,000

At 40,000 the difference disappears.

Obio Agricultural and Mechanical College, Columbus, April, 1876.

ART. LX.—*On a Bolide of January 31st, that passed over Kentucky;* by J. LAWRENCE SMITH.

ON the afternoon of the 31st of January, at five and one-half o'clock, while crossing one of the streets of Louisville, my attention was suddenly arrested by a magnificent meteor crossing the heavens. I first saw it at 60° above the horizon, and it disappeared to my view behind the houses at an elevation of about 20°. It was pear-shaped, and very bright, and remained in view for two or three seconds. Its apparent size was about one-sixth that of the disk of the moon. It did not separate while under my observation, nor did I hear any noise. On asking, through the medium of the public prints, for the observations of others, I received some fifteen communications, from an area one hundred and twenty miles in diameter.

To a number of the observers an explosion was visible, producing several flashes of light, of different colors. This occurred about ten degrees above the horizon. On exploding, all the fragments disappeared instantly except the largest, which also disappeared before reaching the horizon. Some observers saw sparks flying off from the ball, and a short stream of light behind it. One or two think they heard a whizzing noise and at the time of bursting heard the explosion. All agree in stating that the direction was from northwest to southeast. Nothing has yet been heard of any fragments having been collected. My opinion is that it fell about the range of the Cumberland Mountains in Kentucky, or in the northeast of Tennessee.

This is the third bolide in three consecutive years that it has been my good fortune to witness, in their passage over Louisville, but the fragments of none of them have been obtained. They all were passing from the northward to southward.

ART. LXI.—*Notes on the Sensitiveness of Silver Bromide to the Green Rays as modified by the Presence of other Substances;* by M. CAREY LEA.

SEVERAL investigations made at different times during the past years on the sensitiveness of silver bromide to rays of different refrangibilities, led me to the conclusions: 1st, that its sensitiveness to the different rays could be distinctly modified (increased or diminished) by the presence of various bodies, colored and colorless; 2d, that no relation could be traced between the color of the modifying body and the refrangibilities of the rays to which the sensitiveness was modified. During the past winter, I have carefully re-examined the question, which is an important one both in its theoretical and practical relations, and have found my conclusions in all respects confirmed. And I have during the past winter been occupied with a single portion of the subject, namely, the action of the green rays, as a special study.

In this investigation I have pursued the same general method as before; that is, I have used colored glass whose transmitted rays have been carefully studied with the spectroscope. There is no doubt in my mind that this method of examination is capable of giving results as valuable as those obtained by the use of the spectrum. It may be said in fact that the subject requires for its full elucidation, the use of both methods. To those who may imagine that the results of the exposure to the spectrum are the more reliable, it may be interesting to have specified the weak points of that method.

The *relative strength* of the impression produced by different portions of the solar spectrum on a sensitive surface will always depend upon the intensity of the light employed and the length of exposure. It has already been proved that silver iodide and bromide are sensitive to every part of the spectrum. It follows that any and every part of the spectrum may be photographed upon plain iodide or bromide if only the exposure is sufficiently prolonged. The longer the exposure, the stronger will be the impression produced by the less refrangible rays as compared with the more. Also, it is known that by a system of masking, Prof. John Draper has succeeded in photographing the whole spectrum at once; that is to say, he was able to hold back the action of the more refrangible rays until that of the less was sufficiently strong. The masking was of course done with red or yellow media. Now, when pigments of these colors are extended over sensitive films, what is this but a sort of masking, which retards the action of the more refrangible

rays while freely permitting that of the less? Even supposing these pigments to be chemically inert they would check the action of the blue end of the spectrum and render it possible by a longer exposure to obtain both together. Even a longer exposure would not be absolutely essential, a more powerful or a longer development may take its place, being rendered possible by the diminished impression of the blue end.

If, then, it is alleged that by coloring a film of silver bromide with *red* pigments, the sensitiveness to *yellow* rays is increased, we are at once moved to reply that such a result is no proof of a chemical or photochemical action exerted by the red pigment; that precisely the same result might be expected if the red substance were chemically inert, or if it were extended over a glass surface and simply interposed in the path of the rays, between the prism and the film, without even coming into contact with the latter. Many results that have been published are liable to this fatal objection. It has been proposed to modify the form of experiment by applying the color to the front of the plate and exposing on the back, through the glass. But even this does not remove the difficulty. The collodion film containing the silver bromide is exceedingly thin and when moistened, very porous and absorbent. Any soluble color applied, dissolved in water or alcohol, instantly penetrates it through and through and even moistens the glass under it. And all the colors mentioned by other experimenters as having been subjected to this experiment, are soluble. It is on these results that theories have been based, and they are all susceptible of full and complete explanation in the manner just mentioned.

In matters of photographic experiment such as these now under discussion, there are always three distinct factors: The sensitiveness of the matter, the force of the impression (depending upon the intensity of the light and the length of exposure), and the development. This makes the investigation difficult and deceptive. If we take two identical sensitive films, and submit them to the same exposure, we may get quite different results by varying the development, or with an identical film and development, by varying the exposure. The amount of error and deception liable to be introduced in this way is known to none but those made familiar with it by experience, and consequently for accurate results, these sources of error must be eliminated. There is but one way of doing this: a film must be taken, one portion of it must be washed over with the substance whose action is to be studied, and then the two portions, the plain and that which has been treated, must be simultaneously exposed and simultaneously developed. Both portions must receive the same rays, of equal intensity and for an

equal time, the development must be made by a bath applied to both portions equally and for an equal time. If these conditions are not maintained, the result will be deceptive. The *intensity* of light must be the same and the *duration* of exposure, because the *relative* effect of the different rays will always be proportionate to them. The same plate exposed to the same image for a double time, or for an equal time to an image of double intensity, will give a final result in which the relative strengths are totally different. The relative strength of different parts of the image is also largely modified by the development. I am therefore justified in affirming that no strictly comparative trial can be made except the two images, on the colored and uncolored films, be received on the same plate, simultaneously and for the same time, and be simultaneously and equally developed.

These conditions have never yet been fulfilled in the case of spectral observations. By the use of colored glass they may be maintained with absolute exactness. And when colored media can be obtained which exclude all but a given band of consecutive rays, the effect of colored substances added to the film of silver bromide, in modifying its sensitiveness to this band of rays, may be accurately fixed. Having previously, with the aid of the spectroscope, determined the exact character of this band, we are enabled to speak very decisively of the action of the rays of which it is composed.

In the present investigation I have limited myself to a single question: Does there exist any red substance which is capable of increasing the sensitiveness of silver bromide to the green rays?

For the purpose of this examination, I used three thicknesses of very dark green glass, the limiting wave-lengths of which had been many times measured with closely corresponding results; the widest variation was two minutes of arc, which when it is considered how gradually the band fades out at its borders, and how very faint the illumination is at its extreme limits, is fully as close an approximation as could be expected. The extreme limits of the band, measured to the limit of visibility, were $\lambda 497$ and $\lambda 581$. But the extremities showed an illumination too feeble to have any effectual result. Cutting off the very faint light, the band was reduced to $\lambda 517$ on one side, and $\lambda 569$ on the other, and the rays between these limits may be taken as those whose results were observed.

In order to register the effects produced, a glass negative of a suitable character was placed under these three glasses, and under the negative, a glass carrying the film to parts of which

the coloring matters had been applied. Complete contact was obtained by a pressure frame, and the exposure was made directly to the sun. With a good sunlight, in winter, the exposure was about 45 seconds, corresponding to perhaps 20 or less of summer light. The development was in all cases the alkaline, viz: pyrogallol, and ammonium carbonate controlled with potassium bromide.

As already said, the main object of the research was to arrive at a solution of the question whether any red pigment could be found which would enhance sensibility to the green rays. The following were tried:

Ammonium hæmateate.	Murexide.
Santaline.	Aurine.
Coralline.	Carminic acid.
Rosaniline.	Naphthaline red.
Ferric sulphocyanide.	

In addition to these substances of well-established composition, some pigments were tried whose commercial names are:

Cardinal red.	Rouge ponceau.
Saffranine.	Bordeaux claret.
Cerise.	

With the single exception of coralline, not one of these substances produced the slightest increase of sensitiveness to the green rays.

It was my intention, in the case of finding any red pigments which increased the sensitiveness to green light, to make a careful study of their absorption spectra by means of the spectroscope, but as none such were found except coralline, its spectrum only was examined.

The power of coralline, however, to increase the sensitiveness of AgBr, to green light, cannot be considered as any function of its color, for two most excellent reasons.

1. Coralline exhibits a *still more marked tendency to increase the sensitiveness of AgBr to the red ray than to the green.* This action on the red ray was observed and published by me in March, 1875, and completely disproves of the theory of any special action of coralline upon the green ray. There appears to be a heightening of sensibility to the less refrangible end of the spectrum, rather than to any particular ray.

2. The action on green light is not a function of the color of coralline, because *it is easy to destroy that action without destroying the color.* This singular result is accomplished in the following way.

Coralline appears to be the ammonia salt of a yellow acid. If we place a drop or two of a weak acid, acetic or gallic, in a capsule, and add a few drops of alcoholic solution of coralline,

the deep red color of the solution passes to a clear yellow. With the addition of more coralline solution, the color reappears with its full brilliancy. But the solution, if too large a proportion of coralline to the acid has not been added, is found to have wholly lost its power of exalting sensitiveness to the green rays, although the amount of color applied be made the same in both cases.

Absorption Spectrum of Coralline.—With a moderately strong solution and a narrow slit, the transmitted band is confined to the red rays. As dilution increases, the band widens, passes the D lines, and transmits all the yellow rays. In all cases the band is continuous, and shows neither intervals nor a second maximum.

Coralline, then, forms no exception to the general rule, as above deduced from the examination of fourteen substances of strong red coloration.

Action of Colorless, or nearly Colorless, Substances on the Sensitiveness to Green Rays.

The following substances examined, gave an increase of sensitiveness:

Potassic arsenite.	Morphia acetate.
Argentic arsenite.	Tincture of capsicum.
Salicine.	Ammonium valerate.
Codeia.	Caffeine?

It appears, therefore, that it is not among the colored, but the colorless substances, that we must look for those capable of enhancing sensitiveness to green light. While not a single red substance could be found that possessed that property, no less than eight colorless substances exhibited it.

The following substances neither increased nor diminished the sensitiveness:

Ammonium hippurate.	Phloridzin.
" mucate.	Parabanic acid.
" malate.	Tincture of aloes.
Plumbic arsenite.	Potassic formate.

It was a little uncertain whether two of these substances, phloridzin and potassic formate, did not give a slight increase of sensitiveness.

The following colorless substances distinctly diminished the sensitiveness to green light:

Brucia.	Gentianine.
Strychnia.	Podophylline.
Narcotine.	Aconitine.
Daturine (tinct. of stramonium.)	Asparagine.
Acid ammonium urate.	Berberine.
Piperine.	

Finding, therefore, no red substance capable as such of increasing the sensitiveness of AgBr to green light, and, on the other hand, many colorless substances which have that effect, I am entirely confirmed in the opinion originally expressed in the pages of this Journal, that there exists no relation between the color of a substance and that of the rays to which it increases the sensitiveness of silver bromide.

Philadelphia, March 13, 1876.

ART. LX.—*Contributions from the Sheffield Laboratory of Yale College.* No. XXXIX.—*On the Chemical Composition of Durangite;* by GEORGE J. BRUSH.

IN an article* on this rare mineral, published in 1869, I expressed the hope to make further examination of its chemical composition whenever sufficient material could be obtained for this purpose. Several years elapsed before any new discoveries of the mineral in Durango were made. I am again indebted to Mr. Henry G. Hanks of San Francisco for a new supply of the crystals obtained in recent explorations. These crystals are much smaller than those previously examined, being from one to three millimeters in diameter, and they are of a darker shade of color. The former were loose detached crystals, while these are associated with, and in some cases attached to, rolled fragments of crystallized hematite and cassiterite. The density of the small dark colored crystals is 4·07, while that of the purest of the bright colored crystals before described is 3·937. In all other physical characters there is a perfect correspondence between the two varieties.

The chemical examination of the dark colored small crystals has been undertaken, at my request, by my assistant Mr. George W. Hawes, first to estimate the amount of fluorine in the mineral, which in two determinations he found to be 7·67 and 7·49 per cent, and Mr. Hawes has also placed at my disposal for this article a complete analysis of this variety of the mineral. The fluorine was determined directly by Wöhler's method as modified by Fresenius.† To determine the arsenic acid, and the bases, the mineral was decomposed by sulphuric acid, and the arsenic weighed as sulphide; the alumina, iron and manganese obtained in the analysis were carefully examined to ascertain their purity. The soda and lithia were

* This Journal, II, xlviii, 179.
† Fresenius' Quantitative Analysis (Johnson's edition), p. 406.

weighed as sulphates and then converted into chlorides and separated by ether and alcohol.

The results of the analysis are as follows:

	I.	II.
Arsenic acid,	53·11	....
Alumina,	17·19	....
Ferric oxide,	9·23	....
Manganic oxide,	2·08	....
Soda,	13·06	....
Lithia,	0·65	....
Fluorine,	7·67	7·49
	102·99	

The percentage of fluorine, 7·67, corresponds to 3·23 per cent of oxygen, which, being subtracted, the analysis foots up 99·76, and calculating the percentages of the elements we have the following:

	As	Al	Fe	Mn	Na	Li	O	Fl	
	34·63	9·18	6·50	1·45	9·69	0·31	30·33	7·67	= 99·76
Atomic ratio,	·462	·335	·116	·026	·421	·044	1·894	·404	
	·462	·477			·465		2·298		

Multiplying this ratio by the quantivalence of the elements we find that the ratio of R : R : As is 1 : 3 : 5 with 9(O, Fl.)

The formula may therefore be written $(Na, Li)^2$ (Al, Fe, Mn) $As^2(O, Fl_2)^9$

The ratio of oxygen to fluorine in the mineral is as 9·4 : 1.

This is a confirmation of the conclusion drawn by me from the analysis of the lighter colored crystals described in the original paper.*

The mean of my two analyses gave:

Arsenic acid,	54·16
Alumina,	20·35
Ferric oxide,	4·92
Manganic oxide,	1·43
Soda,	11·76
Lithia,	0·75
Fluorine,	undetermined

The variety examined by Mr. Hawes contains less alumina, and considerably more iron, which accounts for its darker color and slightly higher specific gravity. His results prove the mineral to be an arseniate analogous in chemical composition to amblygonite as suggested in my previous paper.

* Loc. cit.

ART. LXIII.—*The Geological Survey of Brazil. First Preliminary Report made to the Counsellor Thomaz José Coelho de Almeida, Minister and Secretary of State for Agriculture, etc.;* by CH. FRED. HARTT, Chief of the Geological Commission of the Empire of Brazil. Rio de Janeiro. 1876.*

ON the first of May, last year [1875] I had the honor of being appointed chief of the Commission charged with the undertaking of a geological survey of the Empire. At the same time Dr. Elias Pacheco Jordao was chosen assistant, and Messrs. Orville A. Derby and Richard Rathbun were appointed assistant geologists. The government having given me authority, I engaged, as the photographer of the Commission, Senhor Marc Ferrez, photographer of the Royal Navy.

While awaiting instructions, and with the permission of his Excellency the Minister of Agriculture, I went with Commander E. P. Wilson to the district of Sao Gonçalo, in the southwestern part of the province of Minas Geraes, for the purpose of inspecting the auriferous tract pertaining to a grant in which the latter was interested. I examined with care the region between Bella Vista, on the Don Pedro II railroad and Sao Gonçalo, including the gold mines of that locality and in the vicinity of the city of Campanha, verifying the occurrence of gold in three distinct deposits.

First, it is found in gneiss of what appears to be the upper part of the Archæan series (Laurentian), the metal being distributed in more or less irregular veins, apparently conforming in direction with the stratification of the rocks. Throughout this section the gneiss is very much decomposed, remaining, however, *in situ*, the decomposition at times extending to a depth of 30 meters or more. While in the solid gangue the proportion of gold is not great enough to pay the cost of working, it has been extracted with profit in many places from the decomposed portion of these same lodes. It is quite probable that this softened rock contains proportionally more gold than the solid gneiss, owing to the accumulation of the contained

* Translated and arranged for publication in this Journal by Theo. B. Comstock, Ass't Professor, in charge of Geological Department, Cornell University, Ithaca, N. Y. This document has not yet been published in Brazil. A copy of the original manuscript in the Portuguese language has been kindly furnished to the translator, with full liberty of action. The report has been shortened by the omission of not a little concerning the details of the Survey, which can have no special interest to the readers of this Journal. The mode of arrangement and construction of sentences differs somewhat from the original, but mainly in cases in which conciseness is gained without the sacrifice of perspicuity. Statements of fact or opinion will be found to correspond as closely as possible with the ideas of the author. Explanatory words within brackets are added by the translator. Words enclosed in parentheses occur thus in the original.—[T. B. C.]

metal of the lower portion in this part of the vein. Action of this nature was first demonstrated by Dr. James E. Mills in the auriferous district of Rio Grande do Sul and has been confirmed by the observations of Viscount de Barbaçena in his mineralogical studies of the auriferous gneiss of Minas Geraes.

Secondly, the gold occurs in the lower part of a deposit of red earth, which covers the whole surface of this region. This is a mechanical mixture of the ingredients of the decomposed gneiss, the local origin of which is not perfectly evident. All parts of the earth are not equally rich, and the gold is probably distributed in some relation to the outcrops, as has been shown by Dr. Mills in the eastern part of the province.

Thirdly, some gold is found in the alluvial deposits of the river-valleys, and in the vicinity of the ancient excavations of Sao Gonçalo and Campanha; the abundant "waste" also contains a considerable quantity of the metal.

Notwithstanding the small amount of gold and the fact that the richer deposits have already been extensively washed, this section appears to be worthy of scientific study, and, probably, by the application of methods similar to those employed in the California *placers*, the region may yet become productive. To this end are required the detailed exploration of this part of the country, the limitation of claims and the introduction of a cheap method of extraction. A survey of the character mentioned will probably be soon made.

Last year, Dr. Mills spent about six months in the study of the auriferous region of Minas Geraes, where he succeeded in discovering and applying the law of the distribution of gold, especially of its occurrence in the series of rocks characterized by the presence of *itacolumite*,—a law extremely important in its bearing upon the future development of the resources of that province. This gentleman has promised to give me a complete report, in which he will not only enunciate and illustrate this law, but will also include all the scientific results of his interesting explorations.

For several years past I have been engaged in the systematic examination of the border of the Brazilian plateau for the purpose of discovering and critically studying the different geological formations, which are there better developed and more fossiliferous than in the interior, being convinced that I could thus most quickly obtain a sure basis for the study of the general geology of the country. Having received instructions for continuing those studies by beginning in the northern provinces and proceeding southward, I judged it best to inaugurate the labors of the Commission by the exploration of the coast of Pernambuco. On the 10th of July [1875] I left Rio for that province, accompanied by Drs. Jordao and Freitas, and Senhor

Ferrez. Opening a provisional laboratory [in the City of Pernambuco], I commenced the examination of the vicinity, soon discovering limestone beds of the Cretaceous formation containing many species of fossils. The explorations were continued northward as far as Catuáma. At Maria Farinha, Cretaceous rocks were found so rich in fossils that several weeks were spent in carefully studying the formation, making a map of the locality, determining accurately the position and sequence of the strata, and collecting enormous quantities of fossils, among which are very many new species. Other collections were obtained from the vicinity of Olinda, from Iguarassú, from the island of Itamaracá, and at Catuáma.

I studied with especial care the limestones which are used for lime-making, analyses of which will be given in my report, and I am also preparing for the same report a chapter on the manufacture of lime and the construction of calcining furnaces.

The examination of the coast was then continued as far as Santo Agostinho, including a reconnoissance along the line of the railroad to Una, with excursions from several points upon both sides. The geology of this portion of the country is, however, extremely monotonous and of little interest.

At the same time I examined carefully the reefs along the coast,—whose geological features are of the highest importance to the country. As I have already indicated to your Excellency, these are of two classes: 1. *Coral Reefs*, composed of calcareous material derived from the débris of certain species of Polyps, Acalephs, and calcareous plants, and 2. *Consolidated Praias* [Beaches], made up of compacted siliceous sand. The reef of Pernambuco is a representative of the latter class This I examined very minutely, and, with the aid of Drs. Jordao and Freitas, made a map of a portion of it. Senhor Ferrez, under my direction, procured a fine series of photographs exhibiting its structure and appearance.

In the study of these reefs a magnificent collection of corals was obtained, including hundreds of large specimens, with many new species. Along with these, and with very little trouble, we gathered large numbers of marine animals, such as fishes, Echinoderms, Crustaceans, etc., etc., among which there is an extraordinary variety of unknown forms.

In September I went with the members of the Commission to make a reconnoissance along the Sao Francisco River to a point a little above the rapids of Paulo Affonso. We ascended the river in a sailing-boat as far as Piranhas, the limit of navigation. At that place, thanks to Senhor Ventura, we found prompt conveyance to the falls, where we remained eight days. Senhor Ferrez took a series of views of the most characteristic points. This was an extremely laborious task, and I cannot but com-

mend him for the firmness with which he struggled against great difficulties and for the good results that he obtained. As the rocks of the *cachoeira* [rapids] are excessively black and the water is white, it was very difficult to photograph both at the same time. On this account I thought it better to make several separate photographic studies of parts of the *cachoeira* which could be mounted as one picture. I hope that I shall be able, by means of the geological, topographical and photographic material collected, to present clear and exact ideas of this wonder of Brazil.

From this place a trip was made to the Serra* de Maria Farinha, distant about five *leguas*.† From the summit of this ridge, at an altitude of two thousand feet or more, may be seen a very large portion of the provinces of Sergipe and Alagoas, with parts of the provinces of Bahia and Pernambuco, and thus a very accurate idea of the topography of the included area may be obtained. All this portion of the country is composed of gneiss and related rocks, forming a plateau less than one thousand feet in height, and nearly level or with very slight undulations. As the region is arid, there has been scarcely any decomposition of the rocks, and the effects of water action are not very evident, owing to the absence of rain during the greater part of the year. There is no vegetable mould, but the rock is covered with a layer of sand a few inches in depth. The vegetation is such as is peculiar to arid plains—gigantic cactuses, the *xique-xique*, *faxeiro*, *mandacarú*, etc., being abundant. The rivers run in shallow channels, and are completely dry during a great part of the year, as are also the small lagoons which abound on the plain just as upon its continuation in the interior of Bahia.

From point to point peaks or short *serras* rise abruptly from the plain, like islands in the sea, seldom attaining an altitude greater than twenty-five hundred feet. In the provinces of Sergipe and Alagoas the serras are commonly composed of gneiss or some other rock of the same series. Between Piranhas and the rapids, however, small ridges of sandstone are encountered, and in the provinces of Bahia and Pernambuco, in the neighborhood of the Sao Francisco River, there are large serras and high *chapadas* [table lands] composed of the same rock. Such are the serras of Tacaratú. Long ago this sandstone covered the whole of this region; but by the action of the sea during the elevation of the Brazilian Plateau, and afterward by the action of the pluvial waters, these beds were denuded over a large portion of the country, leaving only the isolated fragments now forming the table-topped hills which abound in the valley of the

* The term *serra*, as used in Brazil, signifies a rocky ridge, usually more or less serrated in outline, although even table-topped hills are often thus designated.—[T. B. C.]

† The Portuguese *legua*, or league, is equivalent to nearly 1·6 English miles.—[T. B. C.]

Sao Francisco. This river once ran over these beds at a height of one thousand feet, more or less, above its present level, excavating its channel in the sandstone until it had cut through to the gneiss. Above the rapids the river now courses almost over the surface of the plain, its channel being but slightly indented; but upon arriving at the rapids it is suddenly precipitated by a series of magnificent waterfalls through an exceedingly narrow gorge, the depth of which immediately below the rapids is from 80 to 90 meters. This gorge, or cañon, with its walls nearly or quite vertical, extends as far as Piranhas, the river in this portion being much broken by rapids. Below Piranhas the river valley still maintains its cañon-like character, although its width is increased.

Like Niagara, these falls are slowly retroceding, but in a different manner. * * * * *

At the Cachoeira de Paulo Affonso the water passes over gneissic rocks. These do not here suffer decomposition or disintegration by frost, but they are much eroded by transported sand and stones, which produce extraordinary effects, by excavating innumerable pot-holes that soon communicate and allow masses of the rock to fall away. In my final report, the region of the cachoeira will be very carefully described, as well as the geology and physical geography of the lower Sao Francisco.

We returned to Pernambuco at the end of six weeks, and a few days later the bulk of the collections, filling sixty large boxes, were sent to Rio de Janeiro.

Dr. Jordao becoming ill at this juncture, I permitted him to return to the capital [Rio.] As my two assistants, Messrs. Derby and Rathbun, had not yet arrived, and beginning to feel the need of help, I called upon my former assistant, Mr. John Caspar Branner, who, being then in Rio, came at once to my aid, performing very valuable services. He is still employed by the Commission.

After shipping the collections, I returned to Maria Farinha, with Dr. Freitas and Mr. Branner, in order to finish the study of the Cretaceous beds and to examine the coral reefs. In ten days we returned again to Recife [another name for the city of Pernambuco] with a large vessel loaded with fossils, etc. Having been informed that your Excellency desired to exhibit some of the results of the Commission at the National Exposition [held at Rio Janeiro, January, 1876] the new collections were packed in seventy more cases, and I returned with them to the capital in December, accompanied by Senhor Ferrez. * *

While at Pernambuco, I procured a large barque from Mr. Frederico Soares, of Maria Farinha, and sent Dr. Freitas and Mr. Branner to explore the geology of the coast and its reefs as far as Parahyba do Norte,—a trip which was made with good results.

Afterward, Dr. Freitas returned to Iguarassú, where he obtained a fine collection of Cretaceous fossils, including many specimens of shark's teeth and of the teeth of an enormous reptile which is unknown to me. Mr. Branner then continued his study of the coast south of the Cape of Santo Agostinho, examining the reefs, from which he has sent me an interesting collection of corals and other objects, embracing many new species. He also sent photographs of a number of important points. In the beginning of February [1876], Messrs. Freitas and Branner, after sending me forty additional boxes of specimens, went to Aracaju, in the province of Sergipe, to study the Cretaceous deposits. They have already [March 5] made a large collection of fossils, especially of *Ammonites*, *Ceratites*, *Natica*, *Janira*, etc., with numerous forms not before obtained from Brazil. * *

Upon arriving at Rio de Janeiro, a building was hired, the collections were unpacked, and I began to arrange a series of specimens for the Exposition, Dr. Mills assisting me in the work. About the middle of the month [December, 1875] Messrs. Derby and Rathbun arrived, bringing new collections, including a typical series of the Carboniferous and Devonian fossils of the Amazonas and some North American fossils to compare with them. These gentlemen at once aided me in the preparations for the Exposition, and while this lasted they took charge of the other collections. In the meantime Senhor Ferrez mounted for the Exposition a collection of one hundred photographic views and prepared two albums containing a nearly complete series of the photographs taken for the Commission. As it was possible to expose but a small portion of the collections, there were exhibited only a series of the Cretaceous rocks and fossils, with another series illustrating the structure of the reefs, and the collections brought by Messrs. Derby and Rathbun. * *

On the 1st of February, Messrs. Derby, Rathbun and Ferrez were sent to Bahia, to commence the study of the geology of the vicinity and to continue the examination of the reefs. They established themselves at the station of Plataforma, and have to this date [March 5] been engaged in tracing the limits of the areas occupied by the different formations at the northern part of the Bahia de Todos os Santos [Bay of All Saints], in collecting Cretaceous fossils, and in the study of the reefs. Already they have obtained a large quantity of fossils,—teeth, bones and scales of reptiles and fishes, together with Mollusks and Crustaceans. In connection with the study of the recent formations and the reefs, they have also made a splendid collection of marine animals.

Two years ago, Mr. Herbert H. Smith, one of my assistants on the Morgan Expedition of 1870, was engaged in scientific studies in the province of Pará [on the Lower Amazonas], in some measure under my direction. Since that time he has

gathered a very extensive collection of insects, numbering, as he assures me, many thousands of species. This collection is now owned by Mr. Smith, and it is of so great value that I feel it my duty to call the attention of your Excellency to the matter, suggesting that it may be advisable to take steps toward securing at least a complete set of the species for the National Museum.

In accordance with the request of your Excellency, I accepted the Directorship of the geological section of the National Museum. After inaugurating the plan and arranging the work for my assistant during my absence, I propose to leave the city to continue my studies in the north.

My prospective journey is as follows: to leave Bahia for the diamond fields, and after examining these to proceed as far as the Rio Sao Francisco, to a point not yet determined. I intend to visit the watershed between the Sao Francisco and Tocantins rivers and to determine its character, afterward descending the Sao Francisco to the vicinity of the rapids of Paulo Affonso. From thence I expect to make a trip to the Serra de Araripe, and then to visit the locality of fossil fishes to examine the Serra de Ybiapaba, striking the sea coast probably at Ceará.

After making this expedition and reviewing the work of the assistants, who will be left along the coast in the provinces of Bahia, Sergipe and Alagoas, I ought to have a somewhat clear idea of the general geology of the northeastern portion of the empire, a region concerning which we have now very little information. This journey will probably occupy about four months. At the close of the exploration I propose to return to Rio de Janeiro with the members of the Commission to arrange and describe the collections and to prepare a report *in extenso* upon all the results obtained by the Commission with descriptions and engravings of a large number of Brazilian fossils.

Addendum by the Translator.

A letter received from Professor Hartt, bearing date, Rio de Janeiro, March 25, 1876, gives some particulars concerning the work accomplished since the writing of the foregoing report. He states that Messrs. Derby and Rathbun have met with most excellent results at Bahia, while Dr. Freitas and Mr. Branner have made yet another very large collection of Cretaceous fossils from the Maröim region. Mr. H. H. Smith had also done characteristic work upon the Amazonas, amassing extended and valuable collections. Professor Hartt himself was about ready to start for the interior.

By the same mail a letter was received from Mr. O. A. Derby, dated Santo Amaro, near Bahia, March 26, 1876. He writes: "We have found some rich deposits of Cretaceous fishes and

reptiles in this vicinity and are working them up with care. I do not know as yet what we have, but am certain of several species of Crocodiles and think we have *Iguanodon.* * * * Branner reports quantities of fine Cretaceous fossils from the Province of Sergipe, where he is now." * * * * * * *

"We are now engaged in an exploration of the bay [Bahia de Todos os Santos] and are in a little town four hours by steam from the city [Bahia]. The geology of this vicinity is mainly Cretaceous and Tertiary and quite interesting, though one should have a dozen pairs of eyes to study it. Sections are hard to find and when found more difficult to understand properly. The rock is much decomposed and about a dozen different things present almost the same appearance when in a state of decomposition."

"I have visited a diamond locality. * * * They occur in gravel which is either late Tertiary or modern."

A collection of Brazilian auriferous ores, Professor Hartt writes, will be exhibited at the Centennial Exposition in Philadelphia. The friends of the Professor will be pleased to learn that he has removed with his family to the mountains back of Rio, where all are safe from the ravages of the yellow fever.

Letters for the members of the Commission should be sent enclosed to Major O. C. James, Secretario do Commissao Geologica, Caixa no Correio No. 126, Rio de Janeiro, Brazil, to whom all business connected with the survey may be entrusted. Questions which can be answered by the undersigned will receive due attention. THEO. B. COMSTOCK.

Ithaca, N. Y., May 5, 1876.

ART. LXIV.—*Notice of the Meteoric Stone of Waconda, Mitchel County, Kansas;* by CHARLES UPHAM SHEPARD, Sr., Massachusetts Professor of Natural History in Amherst College.

FOR my first knowledge of the meteorite of Waconda, Kansas, I am indebted to Dr. George W. Chapman of that place. This gentleman wrote me on the subject during my absence from the country the past summer, and it was not until lately that the correspondence was renewed which has led to the information now afforded. From his letters and a few grams of the stone transmitted by post, I am enabled to give the following partial description,—reserving a fuller account until my return to the north, when I expect to receive the large mass from which the fragments sent were detached.

The stone was found two years since, lying above ground, in the grass, upon the slope of a ravine, at the distance of two

miles from the village of Waconda. Many pieces were then broken from the mass, leaving about one-half, whose present weight is fifty-eight pounds, half of which is still covered by the original crust. The specimens transmitted show a freshness equal to that of any newly fallen stone, although they came from the immediate surface,—a circumstance obviously pointing to the recentness of the fall. I have known instances where stones exposed only a few weeks to the weather have suffered a decided oxidation, whereas no such change seems to have occurred in this case.

Its cohesion is about that of the average among meteoric stones. In this respect, as well as shade of color, it corresponds very nearly to the Searsport (Me.) stone, of May 21, 1871; but in structure it differs by being less oolitic. Indeed, it is only obscurely so at all,—the individuals that are distinct being rather granular, often with well-marked angles, some of which suggest the species augite; others, those of forsterite (variety boltonite). There is considerable amorphous whitish matter interposed among the grains (in which they may be said to be imbedded), which is doubtless a mixture of minerals, and may consist of chladnite with some one or more of the feldspars. The chamasite (nickelic iron) is present in thickly scattered, very minute, rounded, lustrous grains, requiring for the most part the use of a lens for their discovery; while the troilite (magnetic pyrites) is now and then seen in considerable grains, or ovoidal aggregations of imperfect crystals. The crust is rather thicker than usual, of a dull iron-black color, with a slight tinge of brown, and much crumpled or reticulated. The specific gravity of a fragment weighing 4·35 grams (of which two-fifths were covered by crust) is 3·810; that of a fragment without crust, weighing 3·57 grams, is 3·58.

By mechanical analysis the stone gave 5·66 per cent of chamasite, and 1·34 per cent of troilite. The earthy portion was rather more than one-half decomposed by aqua regia, the soluble portion, after the separation of the silica, giving magnesia, and protoxide of iron (with a little lime) in the usual proportions of chrysolite. The matter not attacked by acids probably belongs to augite, some feldspathic species, and chladnite.

There exists a rumor that a second stone has been found, twelve miles distant from the first; but it lacks confirmation.

It is very likely that the exact date of this meteoric fall will yet be ascertained, inasmuch as it must have taken place very lately, and, without doubt, was attended with a notable report.

Charleston, S. Car., March 16, 1876.

ART. LXV.—*Paleozoic subdivisions on the 40th Parallel;* by CLARENCE KING.

THE geological exploration of the fortieth parallel has covered an east and west section of the Cordilleras from the 104th to the 120th meridian, or from the east base of the Rocky Mountains to the eastern boundary of California, along the fortieth and forty-first parallels. The belt of territory under examination is a little over one hundred miles from north to south. Over the greater part of this area bodies of Paleozoic rocks are observed at intervals. A considerable study of these more or less detached exposures, together with the final determination of a large collection of molluscan fossils, has rendered it possible for us to correlate the various members of the series, and construct with considerable precision a complete Paleozoic section. It is the object of this paper to announce the stratigraphical divisions established in the field, and their relation to the Paleozoic subdivisions as established in New York and in the Mississippi basin.

It may be well to remark that along our eastern boundary, in the region of the Rocky Mountains, the entire Paleozoic series—including Coal-measure beds and strata bearing Potsdam fossils—are embraced within a section from 900 to 1200 feet, the whole entirely conformable and resting discordantly upon an Archæan foundation. In passing westward the series rapidly expands from 1,000 to 32,000 feet. Lithologically, divisions which were lost in the narrow Rocky Mountain Paleozoic zone are established with great volume and persistency over wide areas in Utah and middle Nevada. Finally, in the neighborhood of Battle Mountain, at longitude about 117° 25′, an Archæan land-mass rose to the west of the Paleozoic ocean, interrupting farther continuance in that direction.

The region of the Rocky Mountains represented Archæan islands and shallows, around and over which the sparing sediments were deposited, while toward the westward the general contour of the Paleozoic ocean deepened over a broad basin, which probably continued to a great depth quite against the western shore in longitude 117° 30′. To the southward, from the well-known observations of Dr. Newberry and others, it is evident that this Paleozoic sea very perceptibly shallowed. The northern configuration of the bottom and the depth of the Paleozoic series in at present unknown. It is a striking fact, that wherever, within the limits of this exploration, exposures are made,—and they are very frequent,—from the Primordial to the summit of the Coal-measures, there is never the slightest unconformity between the various members of the series. The

key to the subdivision of the whole Paleozoic is obtained in the Wahsatch Range, where I have observed a single section of about 30,000 feet of conformable rocks extending from the Permo-carboniferous strata, conformably underlying the red sandstones of the Trias, down to low exposures of the Cambrian.

Ignoring such minor subdivisions as we find to be very variable and local, and describing only such as are observed to be persistent and widespread, I will note in their order from the base of the Cambrian upward the important stratigraphical subdivisions, with their position in the New York scheme.

The lowest member of the series consists of a group which rests non-conformably upon the Archæan, and consists of three prominent members: the lowest is a series of siliceous schists and argillites, best exposed at the mouth of Big Cottonwood Cañon, in the Wahsatch Range, and having a total thickness of from 800 to 1,000 feet; over this is a series of quartzite and quartzofeldsitic strata, having limited beds of slate interspersed through it and containing near the top some dark micaceous zones, the whole reaching in Cottonwood Cañon a thickness of over 12,000 feet: the uppermost member is a narrow zone of variable argillites, calcareous shales, and thin, slightly siliceous limestones having in the Wahsatch an extreme thickness of seventy-five feet. The shaley zone and the accompanying slates carry fossils of well-defined Primordial types, but the quartzite and the deep-lying slates have not yet yielded any organic forms. We have therefore in the Wahsatch a series of 12,000 feet, of which the thin summit member carries Primordial fossils, and the vast underlying series is thus far barren. Comparing the quartzites and argillites with those of the Cambrian section in Wales, the likeness is too great to pass unnoticed, and in view of the enormous developments of these low-lying rocks, as compared with the Silurian lying above the Primordial horizon, I have determined to draw a line at the upper limits of the Primordial period to include the uppermost members of the Potsdam epoch, and to consider the whole underlying conformable series as Cambrian down to the point of their non-conformity with the Archæan. In the extreme east of our work, in the region of the Rocky Mountains, the Cambrian formation is of variable thickness and nowhere reaches an exposure of over 100 feet. In middle Nevada the uppermost zone of the Cambrian, equivalent to the calcareous and argillaceous shales of the Wahsatch, is an immense body of dark limestones at least 3,000 feet in thickness carrying Primordial fossils throughout; the downward continuation of the series being there entirely hidden by the overlying Quaternary desert. The fossils obtained by our survey from the Cambrian series are as follows:

Lingulepis Mæra, n. sp.
" ? minuta, n. sp.
Obolella discoidea, n. sp.
" sp?
Kutorgina minutissima, n. sp.
Paradoxides? Nevadensis *Meek.*
Conocephalites (Ptychoparia) Kingi *Meek.*
Conocephalites (Pterocephalus) laticeps, n. sp.
Crepicephalus (Loganellus) Anytus, n. sp.
" " Haguei, n. sp.
" " granulosus, n. sp.
" " maculosus, n. sp.
" " nitidus, n. sp.
Crepicephalus (Loganellus) simulator, n. sp.
" (Loganellus) unisulcatus, n. sp.
" (Bathyurus?) angulatus, n. sp.
Chariocephalus tumifrons, n. sp.
Ptychaspis pustulosus, n. sp.
Dicellocephalus bilobatus, n. sp.
" flabellifer, n. sp.
" multicinctus, n. sp.
Agnostus communis, n. sp.
neon, n. sp.
" prolongus, n. sp.
" tumidosus, n. sp.

Conformably overlying the summit shales of the Cambrian is a body of limestone, which in the Wahsatch has a maximum development of 2,000 feet, thinning out along the southern part of our belt of country in the region of the Little Cottonwood cañon of the Wahsatch to 1,000 feet. This group, to which we have given the name of the Ute Limestone, has thus far yielded only fossils of the Quebec group; but none have been obtained from its immediate summit or base. In western Nevada the calcareous shales of the Potsdam and the limestone of the Quebec have enormously thickened, and the whole body of Silurian and calcareous upper Primordial represent from 4,000 to 5,000 feet of continuous limestone, in which were found fossils of the Lower Helderberg, Niagara, Quebec and Primordial. In the Wahsatch it is certain that the Ute limestone is, with the exception of possibly a few thin members at the top and at the extreme bottom constituting an insignificant fraction of the whole zone, altogether of Quebec; while in the middle of Nevada, in the region of White Pine, Robert's Peak and the Piñon Mountains, more than half of the heavy body of limestone is Primordial, a very limited amount is Quebec, and a very large portion of the upper part of the series—exact horizons being yet undetermined—is occupied by the Niagara and Lower Helderberg. The Quebec is represented by the following fossils:

Lingulepis Ella, n. sp.
" or Lingula, sp.?
Obolella, sp?
Kutorgina, sp. undeterminable.
Orthis Pogonipensis, n. sp.
Leptæna melita, n. sp.
Strophomena nemia, n. sp.
Porambonites obscurus, n. sp.
Rhynchonella, sp.? fragments only.
Ophileta complanata, var nana *Meek.*
Euomphalus (Raphistoma) rotuliformis *Meek.*
Euomphalus (Raphistoma) trochiscus *Meek.*
Raphistoma acuta, n. sp.
Maclurea minima, n. sp.
Cyrtolites sinuatus, n. sp.
Fusispira compacta, n. sp.
Conocephalites subcoronatus, n. sp.
Crepicephalus (Loganellus) quadrans, n. sp.
Dicellocephalus gothicus, n. sp.
" quadriceps, n. sp.
" Wahsatchensis, n. sp.
Bathyurus Pogonipensis, n. sp.
Ceraurus? sp.
Ogygia paraboloidalis, n. sp.
" producta, n. sp.

The Niagara furnishes the following:

Cladopora sp. (resembles C. seriata *Hall*).
Orthis (resembling O. hybrida, *Dal.*, but of larger size.
Atrypa reticularis *L.*
Atrypa resembles *A.* nodostriata. *Hall.*
Illaenus, sp. undet.

The following fossils from the Lower Helderberg horizon were found:

Favosites Helderbergia *Hall.*
Diphyphyllum, n. sp.?
Campophyllum (impressions only).
Crinoidal columns.
Small branching Bryozoans, too indistinct for generic determination.
Crania, sp. undet.
Orthis multistriata *Hall.*
" new sp., (resemb. young of O. oblata *Hall*).
Strophodonta punctulifera *Con.*? fragments only.
Spirifera Vanuxemi *Hall.*
Trematospira?
Collospira, new sp. (allied to C. imbricata *Hall*).
Atrypa reticularis *L.*
Rhynchonella, sp. undet.
Pentamerus galeatus *Dal.* (frag. only).
Cryptonella, sp.? (fragments only).

Directly overlying the Ute limestone is a quartzite which is distinctly developed in the Wahsatch Mountains, varying from 1,000 to 1,600 feet thick. It is usually white or pale green, very fine-grained and slightly schistose toward the top, and contains occasional zones of conglomerate consisting of remarkably smooth quartz pebbles in a fine siliceous matrix. From its characteristic development in Ogden cañon we have called it the Ogden quartzite. It is again met with in western Nevada, where it has a thickness of 700 or 800 feet. This body of siliceous material is sometimes altogether wanting, its place being taken by limestone, the Ute and Wahsatch limestones forming one continuous body, siliceous impurities marking the horizon of the Ogden. In the Wahsatch the Ogden quartzite is overlaid by a limestone of very great thickness, to which we have given the name of the Wahsatch limestone, and whose lowermost fossils in the Wahsatch are Upper Helderberg. In western Nevada also the Ogden quartzite is seen between the upper and lower Helderberg horizons. We have included it provisionally within the Devonian age, considering it the probable equivalent of the Schoharie and Cauda-galli grits.

Next above the Ogden quartzite, as just mentioned, lies the Wahsatch limestone, a body reaching 7,000 feet in thickness in the Wahsatch and over 8,000 in middle Nevada. Although varying slightly in the purity of the material and constantly in its physical aspect, it is nevertheless a single limestone series. The lower 1,200 or 1,400 feet are embraced within the Devonian, and characterized by fossils of the Upper Helderberg and Chemung group, and in a single instance a group which would seem to have the facies of both the Upper and Lower Helderberg. If in the lowermost members there is a mingling of Silurian forms, as may possibly hereafter be proven, it will then be necessary to move the Silurian line higher, so as to include the Ogden

quartzite; but the present evidence would seem to restrict the Lower Helderberg to the region below the Ogden quartzite.

From the horizon of the Upper Helderberg were obtained the following:

Alveolites multiseptatus *Meek.*
Cladopora prolifica *H. & W.*
Acervularia pentagona *Goldf., Meek.*
Smithia Hennahii *Lourd., Meek.*
Diphyphyllum fasciculum *Meek.*
Ptychophyllum? infundibulum *Meek.*
Naticopsis, sp. undet.
Orthoceras Kingii *Meek.*

From the upper members of the Devonian, ranging from the Upper Helderberg to the Chemung inclusive, there were obtained:

Favosites polymorpha *Goldf., Meek.*
Syringopora Macleuri? *Bill.*
Smithia Hennahii *Lourd., Meek.*
Cyathophyllum Palmeri *Meek.*
Strophodonta canace *H. & W.*
Productus subaculeatus *Murch.*
Spirifera alba-pinensis, n. sp.
" argentaria *Meek*, (very closely allied to S. zigzag *Hall*).
Spirifera Engelmani *Meek.*
Atrypa reticularis *L.*
Rhynchonella Emmonsi, n. sp.
Pentamerus, sp?
Cryptonella, sp.?=Rensellaeria? sp. *Meek.*
Paracyclas peroccidens, n. sp.
Pterinea, sp.?
Pleurotomaria, sp. undet.
Isonema, sp.?
Bellerophon neleus, n. sp.
Orthoceras, sp.?

In a single instance, namely, that at White Pine, the Chemung is overlaid by black shales, the probable equivalent of the Genesee group, from which are collected the following:

Leiorhynchus quadricostatus *Hall*= Rhynch. (*Leiorhynchus*) papyraceus *Meek.*
Aviculopecten catactus *Meek.*
Nuculites triangulatus, n. sp.
Linulicardia fragosa = Posidonomya fragosa *Meek.*

From our present knowledge it would seem that the lower 1,200 or 1,400 feet of the Wahsatch limestone is strictly Devonian. The Genesee and the Chemung are followed by beds carrying forms having a close resemblance to the Waverly group, but which are considered by Messrs. Hall and Whitfield as closely allied to the Upper Devonian. They consist of the following species:

Michelinia sp.?
Streptorhynchus equivalvis *Hall.*
" inflatus *H. & W.*
Strophomena rhomboidalis *Whal.*
Chonetes Loganensis, n. sp.
Productus, sp.? (fragments only).
Spirifera centronata *Winch.*
" alba-pinensis, n. sp.
Athyris Claytoni, n. sp.
Athyris planosulcata? *Phillips.*
Rhynchonella pustulosa? *White.*
Terebratula Utah, n. sp.
Euomphalus (Straparollus) Utahensis, n. sp.
Euomphalus latus *var.* laxus *White.*
" (Straparollus) Ophirensis n. sp.
Proetus peroccidens, n. sp.
" Loganensis, n. sp.

The thickness of the Waverly series is not definitely known, since there is quite a gap of barren limestone between it and the next fossiliferous zone. Not far, however, above the Waverly, especially as shown in the Oquirrh Range and White Pine, occur fossils of the true Sub-carboniferous, such as:

Zaphrentis eccentrica *Meek.*
Fenestella, sp. ?
Polypora, sp. ?
Glauconome, sp. ?
Orthis resupinata *Martin ?*
Productus lævicostatus *White ?*
" semireticulatus *Mart.*
" elegans *N. & P. ?*
Productus Flemingi, *var.* Burlingtonensis *Hall.*
Spirifera striata *Mart.*
" setigera *Hall.*
" Keokuk *Hall.*
" sp.? resembles S. imbrex *Hall.*
Athyris subquadrata *Hall.*

From the evidence in the Oquirrh Range it would seem that the Sub-carboniferous and Waverly together cannot be less than 1,000 feet thick. Through the remainder of the Wahsatch limestone, up to its very summit—a thickness of at least 4,000 feet above the Sub-carboniferous—are found at intervals beds carrying distinct Coal-measure forms. This immense body of limestone therefore, represents 4,000 to 4,500 feet of Coal-measures, 1,000 to 1,200 feet of Sub-carboniferous and Waverly, and 1,000 to 1,400 feet of Devonian, all these figures varying slightly according to the general expansion or contraction of the Wahsatch limestone as a whole in different localities.

Next in the series above the Wahsatch limestones occurs a very remarkable bed of siliceous material, which we have named the Weber quartzite from a typical occurrence in the Weber cañon of the Wahsatch Range. Here, conformably overlying the limestone, is a body of quartzite about 6,000 feet in thickness, having a few red sandstones at the base, and occasional limited fine beds of shale interspersed at three or four different horizons through the body, and varied to a considerable extent by thin sheets of conglomerate and rounded quartz pebbles. It has never in this locality yielded any fossils; but its reference to the middle of the Coal-measures is rendered absolutely certain by the collection of great numbers of different Coal-measure fossils from the Wahsatch limestone below and from an overlying body of limestone to be described later. In the cañon of the Weber, this Weber quartzite has a minimum thickness. In the Oquirrh it has been estimated to be 9,000 or 10,000 feet; and unless we have made some errors in the assignments of horizons in western Nevada, it there reaches an even larger figure. To this member of the series we have referred the great body of sandstones with intercalated shales and conglomerates which form the body of the Uinta Range, and there display a thickness of certainly over 10,000 feet, and according to Major Powell, a much greater thickness. The evidence on which this is referred will be detailed in the forthcoming geological report of this exploration. The Weber quartzite is exceedingly variable in its thickness and mechanical condition. For the most part it represents a true quartzite, but here and there at various localities it is less altered and is merely a series of coarse granular sandstones. At several places in the Wahsatch this body of quartzite is exposed between the two Coal-

measure limestones, where there can be no doubt of its true stratigraphieal relations.

Conformably overlying this is a body of about 2,000 to 2,500 feet of limestones, chert-beds, calcareous and argillaceous shales, and some beds of calcareous sandstones and arenaceous limestones, the whole constituting a very variable series, and carrying from the bottom to the top distinct Coal-measure forms. In middle and eastern Nevada the shales and arenaceous beds are wanting, and the whole series is a continuous body of limestone.

In the broken and dislocated exposures of the desert country of Nevada there are many outcrops of limestone disconnected from other formations and only referable by their fossils to the Coal-measures. In such cases it is sometimes impossible to determine whether the body should be strictly referred to the Upper Coal-measures or to the Coal-measure part of the Wahsatch limestone. In consequence of this uncertainty, it is impossible at present to say what species are common to both Coal-measure limestones and to group those which are restricted to the two different horizons. From localities where the data is complete, it is evident that both limestones have many species in common. The combined list of the two is too extensive to be published here but will be found in full in the Paleozoic chapters of our reports.

Overlying the true Upper Coal-measures is a variable body of argillaceous and calcareous shales and mud rocks, with limited beds of limestone and sandstone, containing many ripple marks and unquestionably a deposit of very shallow water. It is composed altogether of fine silted material and contains forms which have been referred unhesitatingly by Meek, and Hall and Whitfield to the Permo-Carboniferous. This series is extremely variable and reaches a maximum of 500 feet. While through the Upper Coal-measures there is more or less evidence in the country east of the Wahsatch of a progressive shallowing, there is a decided difference between the Coal-measure proper and the Permo-Carboniferous. The two are apparently quite conformable, yet at the same time a very great change of condition has taken place and it is possible that subsequent study will show a slight discordance of position. If so, the extent of the disturbance of the pre-Permian members has been very slight east of the Wahsatch, while to the west of that range the Permian is wanting.

The following are some of the characteristic fossils :

Aviculopecten curtocardinales, n. sp.
" McCoyi *Meek.*
" sp., *Meek*, (Pal. Up. Mo., plate 2, fig. 10).
Aviculopecten occidaneus *Meek.*
" parvulus, sp. n.
" sp.? resembling Pecten Clevelandicus *Swallow.*
Aviculopecten Weberensis, sp. n.
Eumicrotis Hawni *M. & H.*
" sp. undet.
Myalina permiana *Meek.*
Myacites Weberensis *Meek.*
" aviculoides *Meek.*
" inconspicuus *Meek.*
Schizodus, sp., =S. ovata *Meek.*

From the immense thickness developed in central Utah, the Paleozoic series, there 30,000 feet thick, thins toward the east until as before stated, in the region of the Laramie Hills, it is compressed into 1,200 feet. From the observations of Newberry, and the later accounts of Gilbert, Powell and Marvine, it is clear that it also shallows toward the south, and the observations of the Carboniferous in California would indicate thinning in that direction.

The Archæan body spoken of in western Nevada may or may not have had a continental significance. It would seem, however, from the relations of the Carboniferous in the Blue Mountains of Oregon and Bass' Range in California, that, if a continental mass, it possessed deep westward bays in which the Paleozoic sediments were deposited. It is, however, probable that the Archæan body was only a mountainous region of no very great east and west development, and that the Paleozoic sediments were deposited around it to the north and south.

While as yet no non-conformity has been observed in the whole series from the base of the Cambrian up, there is in middle Nevada an evidence of shallow water and the accumulation of plant-bearing earthy coal beds in the upper part of the Wahsatch limestone. When the detailed stratigraphy to the south of our field comes to be worked out, it is possible that a local uplift will be found near the close of the deposition of the Wahsatch limestone. But otherwise throughout the whole extent we have no indication of a non-conformity. On the contrary, there seems to have been a continuous undisturbed deposition varying between siliceous and calcareous sediments in which the lines of these two types of material have been sharply drawn in a deep oceanic basin over the greater part of the area of Utah and Nevada, while toward the shallow shore in the region of the Rocky Mountains the deposit was more irregularly mixed. Aside from the intimation of a local shallowing at the close of the Wahsatch limestone in western Nevada, the evidences are all of deep-water deposits till near the close of the Upper Coal-measure series, when ripple-marked shales make their appearance, and the Permian depositions thereafter seem all to be of a shoal-water character.

ART. LXVI.—*A Nebula-photometer*; by E. C. PICKERING. (From a letter to the editors, dated Boston, April 5, 1876).

AN examination of the article in the May number of this Journal on the changes on the Nebula M. 17 shows the desirability of accurate photometric measurements of these bodies. I wish therefore to make known the following nebula-photometer in

Page 482, line 5 from top, for Powell read *Howell.*

To measure the brightness of a nebula the various portions are brought in succession into the center of the field and the light varied until the spot disappears. The exact position of each point is found by observing the various positions of any star in the field with regard to the squares. The real motion of the photometer is thus found from the apparent motion of the star. A contour map may then be constructed showing the brightness of the various portions, and would soon show any marked changes in the light of the various parts. The light of the adjacent sky must be similarly measured and subtracted from all the readings. The brightness may be compared with that of any star by throwing the latter out of focus until its disk attains a given size, and a star photometer is thus obtained. Observations on a comet, with contours showing its brightness on various days, would be both interesting and valuable. The brightness of different portions of the moon could be measured by slightly modifying this photometer. By using a very low power the light of an aurora, of the zodiacal light or of different portions of the sky could be similarly measured. For very faint objects it might be better to insert a diaphragm in the eye-piece having an aperture but little larger than the collodion film, thus giving a dark background. Positions could then be determined by the finder or by moving the entire eye-piece by micrometer screws.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On Hydrocellulose.*—In some of the processes in the arts in which cellulose is used, as in paper-making, this substance undergoes a transformation by which it is rendered friable. Aimé Girard has investigated the matter, and finds that this change is owing to the assumption of a molecule of water by the cellulose to form a new body of the composition, $C_{12}H_{22}O_{11}$, to which he gives the name of hydrocellulose. To prepare it, some form of purified cellulose, such as carded cotton, is placed in sulphuric acid of 45° B. in the cold for twelve hours. It is then well washed, pressed and dried. After it is dry, its fibrous character is destroyed by pressure; rubbing between the fingers converting it into a white

powder. Girard explains in this way the brittleness of certain papers bleached with chloride of lime.—*C. R.*, lxxxi, 1105, Dec. 1875.

G. F. B.

2. *On the Decomposition of Stearic Acid by distillation under Pressure.*—Under the direction of Professor Thorpe, JOHNSTON has submitted stearic acid to distillation under pressure, with a view to determine the decomposition products. A copper tube was employed for this purpose, bent twice at right angles. At the second bend from the end, which served as the retort, was an elongation of the tube serving as a receiver. The end of the tube was provided with a stopcock to allow the gases to escape. The stearic acid was heated, allowed to distill over, then run back into the retort, again distilled over, and so on until the acid was completely decomposed. The liquid products were collected and examined. They proved to be hydrocarbons of the marsh gas and olefine series exclusively. The gases resulting were similar, with the addition of water vapor and carbon dioxide.—*J. Chem. Soc.*, II, xiv, 8, Jan., 1876.

G. F. B.

3. *On Liquid Carbon Dioxide in mineral cavities.*—On heating a microscopic slide of quartz containing fluid cavities only to a moderate temperature, HARTLEY was surprised to find that the liquid, previously perfectly visible under the microscope, had disappeared. On cooling, the liquid reappeared accompanied by a sort of flickering movement within the cavity. Experiments on fluid cavities in various minerals made by Brewster in 1823, showed that the liquids all disappeared below 88° F., that their expansion between 50° and 80° F. was 32 times that of water, and their index of refraction 1·2946 in topaz and 1·2106 in amethyst. From these results Simmler, and later, Sorby and Butler concluded that the liquid must be carbon dioxide. The author sought carefully to determine the critical point of the liquid, which he did by immersing the slide in water of known temperature, removing, wiping hastily, and examining. As a result, it appeared that the critical point lay between 30·75° and 31° C., that point for pure carbon dioxide having been fixed by Andrews at 30·92° C. In further corroboration of this view is the fact that when water was also present in the same cavity, the other liquid floated on it; the density of carbon dioxide being 0·83 at 0° and 0·6 at 30°. Moreover, Geissler has shown the presence of this gas in quartz by its spectrum in a vacuum tube in which the quartz was broken. In explanation of the formation of these fluid cavities, the author supposes the silica in hot solution to have come in contact with a limestone under pressure, setting free carbon dioxide which being enclosed in the crystal cavities along with water would on cooling condense to a liquid.—*J. Chem. Soc.*, xxix, 137, February, 1876. G. F. B.

4. *Decomposition of Alcohol by Aluminum and its Iodide.*—GLADSTONE and TRIBE have continued their researches on the action of aluminum in presence of its haloid salts upon organic

bodies. Alcohol for example, which may be boiled for hours with metallic aluminum without action, evolves hydrogen at once when aluminum iodide is added to the mixture, and in amonnt precisely equal to that theoretically obtainable from the aluminum. The residue of the reaction consisted of aluminum ethylate mixed with some iodo-ethylate. The former body distilled over above 275° C., but suffered partial decomposition. Under diminished pressure, a yellowish white solid collected in the receiver, which fused at 115° and boiled about the boiling point of mercury. Analysis showed it to be aluminum ethylate. The same action was observed with amyl alcohol, and with bromide in place of iodide.—*J. Chem. Soc.*, clviii, 158, Feb., 1876. G. F. B.

5. *New Method for producing Condensed Hydrocarbons.*—WATSON SMITH, having observed that naphthalene passed through a red hot tube, loses hydrogen and produces iso-dinaphthyl, sought to increase the yield of this substance by heating the naphthalene vapor with that of some volatile and easily reducible metallic chloride, the chlorine of which should help to remove the hydrogen. A mixture of naphthalene and antimonous chloride vapors passed through a red hot tube filled with pumice, gave an abundant yield of iso-dinaphthyl. The reaction is—

$$(C_{10}H_8)_6+(SbCl_3)_2=Sb_2+(HCl)_6+\left(\begin{matrix}C_{10}H_7\\ \vdots \\ C_{10}H_7\end{matrix}\right)_3$$

The author thinks the reaction general.—*Ber. Berl. Chem. Ges.*, ix, 467, April, 1876. G. F. B.

6. *On Manganese Boride and on the Function of Manganese in Iron Metallurgy.*—TROOST and HAUTEFEUILLE have produced a definite manganese boride simply by heating boric acid in a carbon crucible with manganese carbide. Small dark violet crystals were obtained which afforded on analysis the formula MnBo, containing 27 per cent of boron. When free from an excess of manganese, it dissolves in acids, disengaging hydrogen. Water is not decomposed by it at 100°. Mercuric chloride when moist transforms it at once into manganese chloride, boric, and chlorhydric acids. In this reaction, each gram evolves 1697 calories; while its elements taken free evolve 4184; the difference 2487 calories represents the heat set free by the manganese and the boron in combining. Hence the compound is an energetic one. Iron borides too are stable, unlike the iron carbides and silicides. The authors conclude from their researches that the important part which manganese plays in the metallurgy of iron is due (1) to the formation of compounds which evolve in their production a greater amount of heat than that set free by the corresponding compounds of iron; and (2) to the facility with which these compounds form slags, since in oxidizing they evolve more heat than those which contain the same quantity of iron; especially when, as is the case, they exist in presence of a large excess of metal.—*C. R.*, lxxxi, 1263, Dec., 1875. G. F. B.

7. *On the Occurrence of Platinum, Palladium, and Selenium in Silver coins.*—In a letter to Wöhler, Rössler, of the Frankfort parting office, gives some facts of interest relative to the work done in that establishment. During the last year over 400,000 pounds of silver and 5,000 pounds of gold were parted. The silver is purified by crystallization as sulphate and subsequent reduction to the metallic state by iron turnings. The gold is precipitated from its solution in aqua regia by ferrous chloride and melted in gas furnaces; being obtained 1000 fine in this way. Fine silver, especially that obtained from old coins, contains gold averaging about one-thousandth. It also contains both platinum and palladium, the latter sometimes in so large a quantity that its solution in nitric acid is dark yellow. The silver from Commern and Mechernich in the Eifel showed 0·0058 per cent platinum and 0·0053 per cent palladium. In the last year, the office has obtained from the 500,000 pounds of crude silver worked over, twelve pounds of platinum and two pounds of palladium. To obtain these metals, the solution, from which the gold has been precipitated by ferrous chloride, is reduced again by iron turnings, whereby all the other metals present are precipitated as a black sediment. This is freed from copper by the iron chloride, the residue is dissolved in aqua regia, the traces of remaining gold are removed, the platinum is thrown down by ammonium chloride and the palladium by ammonia and hydrochloric acid. In this way selenium was discovered in this deposit. Since then the sediment is fused with soda and charcoal before treating it with aqua regia; several pounds of selenium a year being obtained from this source. The selenium forms an interesting compound with palladium, which is obtained in hard brilliant plates when the regulus obtained as above is dissolved. These plates are not soluble in nitric acid, nor, when platinum is present, in aqua regia; but on ignition they evolve selenium and are then soluble. They are composed of equal atoms of palladium and selenium and resemble the iridosmine scales very closely, being isomorphous with them.—*Liebig's Ann.*, clxxx, 240, Feb., 1876. G. F. B.

8. *On the Conversion of Olefines into the corresponding Alcohols.*—The considerable similarity between the heptylene obtained from pentamethyl-ethol and the terpenes led Boutlerow to attempt the direct synthesis of the alcohol from the olefine by direct union with water, just as the hydrate of terpin is formed. The heptylene was sealed in a tube with water containing a little nitric acid and alcohol. After a few weeks the heptylene had disappeared and had been replaced by the characteristic crystals of pentamethyl-ethol. Liquid isobutylene was then subjected to a similar treatment and with a similar result; trimethyl-carbinol was produced. Sulphuric acid was found to act upon isobutylene in the same way. This olefine, sealed in a tube with double its volume of a mixture of equal parts concentrated sulphuric acid and water, disappeared in the course of two days, and yielded

trimethylcarbinol. Pseudobutylene, isomeric with the former, suffers a similar change but much more slowly.—*Liebig's Ann.*, clxxx, 245, Feb., 1876. G. F. B.

9. *On the Trimethylbenzols of Coal tar Oil and their Separation from each other.*—JACOBSEN has examined very carefully the trimethylbenzols obtainable from coal tar and has shown that only two, mesitylene and pseudocumol are present therein, the third one which theory points out as possible, not existing in the oil at all. Pseudocumol forms only a single sulpho-acid with sulphuric acid, the salt supposed formerly by the author to be isocumolsulphate of barium being a well characterized double salt of mesitylene-sulphate and pseudo-cumol-sulphate. The two trimethylbenzols found separated readily by converting them into the amides of the sulpho-acids, by obtaining first the chlorides by the action of phosphoric chloride and then the amide by the action of ammonia upon this. By crystallization from alcohol, the two substances, mesitylene-sulphamide and pseudocumolsulphamide, are easily and completely separated, the former being far more soluble. On treating the pure amides with hydrochloric acid, the hydrocarbons were regenerated.—*Ber. Berl. Chem. Ges.*, ix, 256, Feb., 1876. G. F. B.

10. *On the Detection of Phloroglucin and Nitrites.*—When very dilute solutions of phloroglucin and of toluidine or aniline nitrate are mixed and a few drops of a solution of potassium nitrite is added, the liquid, at first clear, becomes turbid and brownish-yellow, then orange, and deposits a cinnabar-red precipitate. WESELSKY, who discovered this reaction, proposes it as a test for phloroglucin and nitrites. One c.c. of a solution, containing 0·0005 gram phloroglucin was mixed with one c.c. of a solution of toluidine nitrate saturated at ordinary temperatures, diluted to 50 c.c. with water and treated with one c.c. of a solution containing 0·001 gram potassium nitrite. In 15 minutes the solution became yellow and in three hours the cinnabar precipitate was obtained. Similar reactions are obtained with aqueous solutions of maclurin and catechin, and decoctions of fustic and hops, in place of phloroglucin.—*Ber. Berl. Chem. Ges.*, ix, 216, Feb., 1876. G. F. B.

11. *On the Succinic acid obtained from Active Tartaric acid.*—Pasteur announced some time ago the existence of an optically active succinic acid, and Kekulé showed that the succinic acid derived from active malic acid was itself inactive. BREMER and VAN'T HOFF, deeming the existence of such an active succinic acid extremely improbable, since its molecule contains no asymmetrical carbon atom, have examined the acid which is produced along with dextro-malic acid, by the reduction of dextro-tartaric acid. The acid in question proved to be absolutely inactive and to agree in all respects with ordinary succinic acid. Hence we have: (1) Dextro-tartaric acid, $CO_2H.\underline{C}(OH).CH(OH).CO_2H$, containing two asymmetrical carbon atoms and rotating the polarized plane $(\alpha)=6°{\cdot}6$; (2) Dextro-malic acid, $CO_2H.\underline{C}H(OH).CH_2.$

CO_2H, containing one asymmetrical carbon atom and rotating $(\alpha)=3°\cdot3$; and (3) Succinic acid $CO_2H.CH_2.CH_2.CO_2H$, containing no asymmetrical carbon atom, and being inactive.—*Ber. Berl. Chem. Ges.*, ix, 215, Feb., 1876. G. F. B.

12. *On the Re-conversion of Paroxybenzoic acid into Salicylic acid.*—Neutral potassium salicylate, as Ost has shown, when heated to 210°–220°, splits up into potassium paraoxybenzoate, phenol, and carbon dioxide; while the sodium salt affords no paraoxybenzoate. KUPFERBERG has succeeded in effecting the inverse reaction and in converting the paraoxybenzoate again into salicylate. 39·5 grams sodium paraoxybenzoate, heated to 280° to 295° for six hours in a current of carbon dioxide gas, yielded 7 grams of salicylic acid; or 56 per cent of the acid present. Salicylic acid is converted into paraoxybenzoate by heating the neutral potassium salt to 220°; paraoxybenzoic acid is converted into salicylic by heating the sodium salt to 290°.—*J. pr. Ch.*, II, xiii, 103, Feb., 1876. G. F. B.

13. *On a new Hydro-oxy-benzoic Acid.*—In the hope of obtaining trimesinic acid—an acid containing three carboxyl groups—EMMERLING and OPPENHEIM oxidized oxyuivitinic acid by means of potassium manganate. The product, precipitated by hydrochloric or sulphuric acid, is purified by crystallization from hot water. It appears in thin colorless needles, fusing at 274°·5, and giving a yellow precipitate with ferric chloride. Analysis gave it the formula $C_7H_8O_3$, the barium salt being $(C_7H_7O_3)_2Ba, (H_2O)_2$ and the silver salt $C_7H_7AgO_3$. Fusion with potash separates water and converts it into benzoic acid.

$$C_7H_8O_3=C_7H_6O_2+H_2O.$$

—*Ber. Berl. Chem. Ges.*, ix, 326, March, 1876. G. F. B.

14. *On Vicin, a Constituent of Vicia sativa.*—Some time ago, RITTHAUSEN described a crystallized highly nitrogenous substance obtained from the seeds of the vetch. He now shows that it is a new body, and has the composition $C_8H_{16}N_3O_6$. He assigns to it the name vicin. A kilogram of seeds yielded 3·2 grams of vicin.—*Ber. Berl. Chem. Ges.*, ix, 301, March, 1876. G. F. B.

14. *Acoustic Attractions.*—M. DVORAK has examined the attractions and repulsions of small pendulums hung near sonorous bodies. A square of paper or a piece of cork is hung by a silken thread, and held near a wooden rod vibrating slowly. Varying the positions of the pendulum it is sometimes attracted and sometimes repelled. These motions seem to be due to the air-currents approaching or receding from the rod, and the motions of the cork served to determine approximately the directions. These results were verified by the motions of a flame and the indications of a very sensitive water manometer. The air thrust aside by the vibrating rod escapes laterally, repelling light bodies. This is replaced by air forming counter-currents toward the rod, producing the effect of attraction. When the amplitude of the vibrations is small, the rod acts like the prongs of a tuning fork, and attraction takes place in every direction.

In front of the opening of a tube of Kundt, is placed a second open tube, giving the same sound as the first, and suspended by two threads. Making the first tube resound loudly, the second tube is strongly repelled. The same effect is obtained if the second tube gives one of the harmonies of the first. Placing two tubes facing each other opposite the tube of Kundt and perpendicular to its axis, they tend to approach each other. With a very sensitive manometer it appears that in a column of air in a state of permanent vibration, the air at the nodes has an excess of pressure. This accounts for the heaping up of water in the loops of a tube of Kundt. It is explained by admitting that the amplitude of the vibrations cannot be neglected compared with their length. It follows that there ought to be a continuous motion of the air from a node to a loop. This might be proved by filling the resonant box of a tuning fork with the fumes of chloride of ammonium and seeing if they are thrown out when the fork is set in vibration.

If a bell is filled with water and a drop of oil allowed to fall on it, the circular film becomes quadrangular when the bell is sounded. The water-currents start from the nodes and accumulate at the loops. A disk of glass is attached to the end of a rod vibrating longitudinally. If a glass drop is hung opposite the disk it will be repelled at the center and attracted around the periphery. There are then, as with air, currents outward at the center, and counter currents inward along the edges.—*Journ. de Phys.*, v, 122.

E. C. P.

15. *Correlation of Forces.*—M. GROVE describes a convenient apparatus for showing the relations between heat, electricity, and mechanical force. The arrangement is as follows:

Two of Clamond's thermo-electric generators are connected for quantity and put in communication with a gram machine, in such a way as to set this in motion. In the circuit is inserted a sort of electric lamp, in which a platinum wire, placed in the center of a small globe (which protects it from agitation of the air) can be raised to incandescence. The only difficulty of the experiment consists in so regulating the length and diameter of the platinum wire, that it may be raised to a red heat while the thermo-electric current retains sufficient intensity to drive the gram machine.

A circuit entirely metallic is thus obtained, with which the following transformations can be effected;

(1.) The gram machine being excluded from the circuit, a portion of the heat, transformed into electricity by the thermopile, reappears as heat in the wire.

(2.) The wire being excluded from the circuit and the machine introduced, a portion of the heat, transformed into electricity in the pile, reappears as work in the machine.

(3.) The wire and machine being included in the circuit, a part of the heat, transformed in the pile into electricity, produces heat in the wire and work in the motor. If we then stop the machine, the incandescence of the wire is increased. The machine being libera-

ted, on the other hand, starts, and the wire cools as its motion increases. The expenditure of heat needed to develop an increasing quantity of mechanical work is thus rendered sensible to the eye.

(4.) Turning the machine in the direction of the rotation produced by the current, a velocity may be reached such that the incandescence shall completely disappear.

(5.) Turning the machine in the opposite direction, there is considerable resistance, and the wire rapidly grows hotter, and is soon fused.

Thus, in the metallic circuit under consideration, the circulation of a given quantity of energy may appear exteriorly in the form of heat, or, as work. If, by an exterior force, we introduce into the circuit an additional quantity of work, the increase of the quantity of energy put in circulation is rendered visible by the incandescence of the wire; any communication outward from the circuit, of a certain quantity of energy which circulates in it, appears, on the other hand, in diminution, or even disappearance, of the incandescence.—*Journ. de Phys.*, iv, 359; *Nature*, xiii, 434. E. C. P.

15. *Change of Volume of Electric Conductors.*—HERR EXNER has measured the change in length of a conductor through which an electric current is passing, by a method free from the error caused by the expansion due to the heat generated by the current. Two pieces of the same wire of nearly equal lengths were hung one over the other, and so connected with a battery that the current might be passed through either. The lower wire passed through a glass which might be filled with water if desired. The elongation was measured by resting the end of the wire on a lever carrying a mirror whose deflection was read by a telescope and scale. The current being passed successively through the two wires a different deflection was obtained in each case, but these were rendered equal by inserting an additional resistance in circuit with that wire whose elongation was greater. The tube was now filled with water so as to carry off the heat generated in the lower wire as rapidly as possible. It was found that the galvanic expansion was only 1·2 to 2·2 per cent of the heat expansion; and no connection was recognizable with the nature of the metal employed. If it be considered that these values, of course, can only by an upper limit, it will follow from the smallness of the effect obtained that there is no sufficient ground for the hypothesis of a special expansion power of the galvanic current. There can hardly be any doubt that the slight expansion which the water-enclosed wire still shows is simply and alone due to the heat remaining in it.—*Nature*, xiii, 452. E. C. P.

16. *Proper Motion of the Stars.*—P. SECCHI points out a new source of error in the measurement of the proper motion of the stars by the displacement of the lines of the spectrum. The author tabulates a number of the observations made by Huggins, Vogel and himself, and those at Greenwich Observatory, and shows there is considerable contradiction in the results.

The question arises whether there may not be some systematic error in the manner of observing or in the instruments. Comparing the dark line F of Sirius with the hydrogen line Hβ of a Geissler tube, he got always the same result — a shortening of the Sirius line occurs (contrary to Huggins) when the telescope was carried along by the clock-work, and the assistant was at the seeker to keep it on a fixed point corresponding to the slit of the spectroscope; but if the clock-work stopped, or the assistant deranged the position of the star, the light line was displaced and came into coincidence with the star line. Dispensing with clock-work the line was found to be on one side or the other, according as the star was looked at on one side or the other of the axis of the telescope. A change was also noticed on turning the spectroscope 180° on its axis. No attempt is made to explain these phenomena, but they are pointed out as possible sources of illusion. — *Comptes Rendus*, lxxxiii, 761, 812; *Nature*, xiii, 480. E. C. P.

II. Geology and Mineralogy.

1. *Paleozoic fossils from a limestone associated with the Serpentine formation* (*Zone of the Pietre verdi*) *of Chaberton* (*Alpi Cozie*).—Prof. B. Gastaldi, in the Bulletin of the R. Comitato Geol. d'Italia for 1875, p. 346, has published a paper on discoveries made by G. Michelotti, a letter from whom is published in the paper. An accompanying geological section, by Michelotti, gives the stratification of the upper part of Mt. Chaberton: No. 1, the dolomitic limestone; 2, anthracitic sandstone of a red color, with black beds containing lamellar hematite, etc.; 3, quartzyte, with beds of gypsum; 4, talcose "calcischist," of a greenish color. Michelotti states that in an amphitheater under the summit of the mountain, bounded by lofty walls of dolomitic limestone, regularly stratified, presenting splendid examples of folding, he found in fragments of the limestone, among some detritus of serpentine, various limestone blocks that were fossiliferous. The fossils were not as well preserved as could be desired, owing apparently to incipient alteration, but they enabled him to distinguish the following genera: *Syringopora*, near *S. abdita*, (a fine species with the long branches one-sixth to one-third of an inch in diameter, and one-eighth to one-fourth of an inch apart, according to the figure); *Halysites;* a branching coral supposed to be a *Favosites;* a joint of a stem of an *Actinocrinus;* a shell of an Ostracoid, referred to "*Cythereis;*" and a sponge, *Lithospongia.* The species indicate that the limestone is probably of the age of the later Upper Silurian, or the earlier Devonian.

Prof. Gastaldi remarks that the limestone beds are superimposed directly on the serpentine, euphotide, and variolite of the region, in some places with a rather sudden transition from one to the other; but also that at other localities the more recent beds of the *pietre verdi* zone, that is, the "*Calcischist*" containing beds of

limestone which afford fossils, seem to pass into the *pietra verdi* by a gradual transition. He supposes, however, that the *pietra verdi* may still be pre-Paleozoic. Yet he offers no evidence to show that it is not merely older Paleozoic. He regards the question one requiring special study, and, in closing, expresses the hope that it may speedily be settled by new discoveries.

The limestone of Mt. Chaberton is stated to be probably equivalent with that of Montaldo Dora, of Lessola near Ivrea, of Rivara, and of Levone; it also occurs at Susa, at the Piccolo Moncenisio, at Seguret, along the French frontier between Frejus and Chaberton, at Balmas, at Rognosa, at Chinivert, and at other places.

The following number of the same Bulletin contains a paper by C. DE STEFANI, sustaining the ground that the serpentine beds of the Apuan Alps *overlie* the Middle and Lower Eocene; that those of several localities in Tuscany are between Cretaceous strata or Eocene; and that those of Elba, Gorgona, Gichio, Jano, and perhaps those of Montecristo and Cape Argentario, are older than the Lower Lias but newer than the Carboniferous.

2. *Eozoon Canadense not organic.*—This is the conclusion of Mr. Otto Hahn after geological and zoological investigations, an account of which is published in the Naturwissenchaftliche Jahreshefte for 1876 of Wurtemburg, and a translation in the Annals and Magazine of Natural History for April. He says, "By my investigation it is established that there is no gigantic foraminifer in serpentine limestone;" "that the most essential characters of the foraminifera, the chambers and the test are not there, but that we have to do with pure rock-formations such as occur every where in serpentine;" that "there is no rock which is so certainly the result of metamorphism, and can be derived from so many minerals, as serpentine;" that he has investigated an immense number of serpentines and always found that they are products of metamorphism." One of the masses of Eozoon which Mr. Hahn examined was from Canada, and bore Dr. Carpenter's label.

3. *Exploration of Lake Titicaca;* A. AGASSIZ and S. W. GARMAN, (Bull. Mus. Comp. Zool., iii, 274).—The Paleozoic fossils collected by these authors about Lake Titicaca are described by Mr. O. A. Derby. Nine are Carboniferous and all but one, *Euomphalus antiquus*, are represented by the same or closely allied species in the United States and Brazil. No Subcarboniferous fossils were met with; but Devonian were found close along side of the Carboniferous at the island of Coati two or three miles from the Lake. The Carboniferous formation extends in a general northwestern direction, and the beds are tilted, often at a high angle. According to Mr. Orrego the formation extends as far north as Callyoma; Prof. J. Orton found, in the same line, Carboniferous fossils at the headwaters of the Amazonas (Pichis R.) and states that Prof. Raimondi, of Lima, has traced the rocks to a height of 14,000 feet, on the Apurimac, between the Pichis and the Cuzco valley.

4. *Note "On the Youngest Huronian Rocks South of Lake Superior;"* by ROLAND IRVING.—In a paper with the above title published in the March number of this Journal, Mr. T. B. Brooks, by an accidental misquotation, makes me responsible for a rock composed of a strange medley of minerals. He says that I mention "these rocks as being coarsely crystalline aggregates 'chiefly of labradorite and orthoclase feldspar, hornblende and some variety of pyroxene.'" I wrote,* "Nearly all of them can, however, be included in two or three general kinds, labradorite, orthoclase felspar, hornblende and some variety of pyroxene seeming to be the chief ingredients." In this I meant to mention the main ingredients of the different kinds, not to say that all of these minerals occur in one rock. I am inclined, with my present knowledge, to follow Mr. Brooks in referring to the Huronian the belt of rocks in Northern Wisconsin, to which the above quotation alludes, as I followed him before in referring them to the Copper Series.† I cannot agree with him in designating the rocks as "granitoid," as, so far as my knowledge goes, they are chiefly rocks of a low degree of silication consisting mainly of labradorite and pyroxene. The general run of the rock in the country occupied by this belt west of Bad River is a dark colored coarsely crystalline mixture of the above minerals, accompanied by hypersthene, magnetite and mica as accessories, as ascertained recently by Mr. Chas. E. Wright from a microscopic examination made by him for me. The "granitoid" rocks which Mr. Brooks has seen occur as patches among these dark colored diabases and allied rocks. In the former only have I noticed orthoclase and hornblende.

University of Wisconsin, April 27th, 1876.

5. *Gigantic fossil bird from the Eocene of New Mexico;* Prof. COPE. (Proc. Acad. N. Sci. Philad., 1876.)—This bird was related both to the Cursores (Struthionidæ and Dinornis) and to Gastornis of the Paris basin. Its size was twice that of the ostrich. Prof. Cope names it *Diatryma gigantea.*

6. *Richmond Infusorial Stratum.*—Mr. Charles Stodder in a paper on the Richmond Infusorial stratum, first described by Professor W. B. Rogers in his Virginia Report of 1840, (this Journal, xlv, 313, 1843), states that Mr. R. B. Tolles examined the stratum as it is exposed in a ravine on the west side of Shockoe Hill, near Richmond, and obtained specimens at the depths, 5, 7½, 10, 11, and 14 feet below the top of the bank, and and also from the north side 40 feet below the top, from a bed which was apparently a continuation of the 14-feet bed, the hill being higher on the north side. The lower layer contains 50 to 80 per cent of organic forms, the uppermost about 20 per cent. The species below this top layer vary but little; while in that they are partly different in species, and the frustules are less broken.

* See paper "On the Age of the Copper-Bearing Rocks of Lake Superior, this Journal, July, 1874.

† Pumpelly and Brooks, this Journal. vol. iii, 1872.

The species of Diatoms peculiar to it are: *Coscinodiscus perforatus*, *Aulacodiscus crux*, *Eupodiscus Rogersii*, and *Mastagonia actinoptychus*. Mr. Stodder gives a list of the species afforded by the several beds.—*Proc. Boston Soc. Nat. Hist.*, xviii, 206, 1875.

7. *Carboniferous Articulates.*—Mr. S. H. Scudder has described (Canadian Naturalist, April, 1876) a fossil larve from a Carboniferous shale near Sydney, Cape Breton, which he refers to a genus near Libellula, and names provisionally *Libellula Carbonaria*; and also, accompanying it, part of a wing of a Cockroach, which he names *Blattina sepulta*.

Mr. Scudder has also published a supplement to his paper on Carboniferous Myriapods (noticed in this Journal, III, vi, 225) in the Memoirs of the Boston Society of Natural History for 1875, giving figures of the specimens there described.

Mr. H. Woodward has described a new fossil Scorpion, from the British Coal-measures, at Sandwell Park and Skegby Collieries, naming it *Eoscorpius Anglicus*; also a gigantic Orthopterous Insect, from Scotland, which he calls *Lithomantis carbonarius*.—*Q. J. Geol. Soc.*, xxxii, 57, 60, 1876.

8. *Note on the Uinta and Wahsatch Ranges: A Correction.*—In vol. III, chapter 7, of the reports of the United States Geological Exploration of the Fortieth Parallel, in mentioning the Wahsatch and Uinta ranges, I stated that the date of their uplift was at the close of the Jurassic period. The chapter was written in 1869, after a brief visit to the two ranges and before the final determinations of horizons and fossils were effected. In 1870–'71–'72 a more careful examination revealed the fact that the more important uplift of these two ranges occurred at the close of the Cretaceous, and not at the close of the Jurassic period. The error had arisen from the extremely close resemblance of certain conglomerates of the lower Eocene with those of the lowest horizon of the Cretaceous. In the Uinta range it was in reality the Eocene conglomerates, and not those of the lower Cretaceous, which we had observed resting unconformably upon the upper shales of the Jurassic. Continued delay in the publication of the geological volumes of our series induces me now to make this correction. In the case of the Uinta there is clearly no non-conformity, from the lowest exposures of the Carboniferous to the highest Cretaceous horizon, while the lowest Eocene rests upon the Cretaceous with distinct non-conformity.

In the Wahsatch the evidence is far more complicated. While the post-Cretaceous disturbance clearly had its profound effect on the range, there are also many facts which confirm our belief that the close of the Jurassic also marked a period of orographical activity, as it did in the Sierra Nevada. CLARENCE KING.

9. *The trilobite, Ceraurus pleurexanthemus, of Trenton Falls, New York.*—Mr. C. D. WALCOTT has given an account of the mode of occurrence of this species and of the characters of the under surface of the dorsal shell, in vol. xi of the Annals of the

Lyceum of Natural History of New York, pp. 155 and 159. He states that the specimens in some layers of the limestone are very numerous: 326 entire specimens were counted in a space measuring 30 feet by 40; and, of these, all but 8 lay with the back downward, the position which exuviæ of the concave form in Ceraurus would take. Their length varies from $\frac{3}{16}$ of an inch to 2 inches. The separated heads are found in immense numbers, and the surface of the rocks is sometimes nearly covered with them.

10. *Glacial phenomena in Jefferson Co., New York.*—According to T. G. B. Lloyd, (Q. J. Geol. Soc., xxxii, 76), the glacial scratches between Philadelphia on the southeast of Theresa and Redwood on the north, (distant ten miles), have a southwest direction, coinciding with the longer axis of most of the lakes between Theresa and Redwood, and with the general course of Indian River. The course is the same as that observed by Emmons near Watertown. Well characterized *roches moutonnées*, with their steepest side facing southwest, occur near Theresa. Mr. Lloyd also describes a pot-hole in the Laurentian granite which is 29 feet deep and 7 to 10 feet in diameter.

11. *Origin of the Porphyry of Marblehead, Mass.*—Mr. T. T. Bouvé, in the Proceedings of the Boston Society of Natural History for January 19, 1876 (xviii, 217), discusses the origin of the red porphyry and red felsyte rock of the vicinity of Marblehead, and proves it to be of metamorphic origin. The felsyte has long been known to contain disseminated grains or fragments of quartz.

He states that in 1862 he observed that the felsyte, near Hingham, was in part pebbly and slaty, and graduated into a conglomerate, and had evidently been derived from the alteration of the conglomerate. His observations since have confirmed this conclusion. [A fine series of specimens was exhibited, illustrating the transitions.]

Mr. Bouvé stated further that he was disposed to include among the rocks having the same origin some, at least, of the underlying syenytes. The succession of rocks as given by others, is—(1) conglomerate; (2) compact feldspar or felsyte, gradually passing into porphyry; (3) porphyry, gradually passing into a rock between porphyry and syenyte; (4) syenyte; and this relation of the beds Mr. Bouvé observes, is itself probable evidence that the causes that led to the changes in the higher portions of the series affected all, though in varying degrees.

The reading of Mr. Bouvé's paper was followed by remarks by Mr. Hyatt, sustaining the view that had been presented respecting the origin of the porphyry. Among his facts he stated that at one point on the ocean side of Marblehead Neck, the variegated conglomerate is altered to compact light-colored felsyte in one direction, and in another to a true deeply colored porphyry, containing distinct crystals of feldspar; and that the included pebble may sometimes be traced until it becomes, without any change of form, a mere spot in the light felsyte matrix, the interior last losing its original characteristics.

12. *Annual Report for* 1874 *of the U. S. Geological and Geographical Survey of the Territories;* F. V. HAYDEN, U. S. Geologist in charge. Conducted under the authority of the Secretary of the Interior. 8vo, with numerous illustrations (88 full paged) and maps. Washington, 1876.—During the year 1874, the explorations of the expedition, under the general charge of Dr. Hayden, were carried on in Colorado, with Denver as headquarters. In the introductory remarks—a letter to the Secretary of the Interior—Dr. Hayden states that the series of older metamorphic rocks, of probable Archæan age, have "alone afforded the precious metals and minerals of Colorado." The volume contains a Report by Dr. HAYDEN on the Lignitic series, the geology of the eastern base of the Front Range, glacial phenomena, and on the Elk Mountains (40 pages); a Report on the geology of the Northwestern portion of the Elk Range by W. H. HOLMES (14 pp.); Report on the features and geology of the valleys of the Eagle, Grand and Gunnison Rivers, and on the detailed features of the formations of the district by Dr. A. C. PEALE (106 pp.); Report on the Geology, etc., of the San Juan division by F. M. ENDLICH (62 pp.); valuable Reports by L. LESQUEREUX on the Tertiary flora of the Lignitic beds, and on the Cretaceous flora of North America, with descriptions of new species (94 pp. and eight plates); Report of W. H. JACKSON, on Ancient Ruins in Southwestern Colorado (13 pp.); besides also a short zoological report by E. INGERSOLL; Geographical and topographical Reports of HENRY GANNETT, S. B. LADD, A. D. WILSON, F. RHODA; also a Report on the superficial deposits of Nebraska, by S. AUGHEY.

No mention is made of Mr. James T. Gardner and his party, who had charge of the Topographical department of the Survey.

Dr. Hayden, in his remarks on the Lignitic series, sustains the views stated in a notice of a paper of his on p. 148 of this volume. He observes that the formations which have been recognized along the eastern front in Colorado above the Archæan are the Silurian, Carboniferous, Triassic (?), Jurassic, Cretaceous and Tertiary. The beds of the Lower Silurian occur along the Black Hills, Big Horn and Wind River Mountains, and near Colorado Springs and Cañon City, but none have been found by the survey for the 200 miles between Fort Laramie and Colorado Springs.

Dr. Peale's excellent report presents a large series of facts with reference to the various geological formations in his district from the Archæan to the Quaternary, and including the igneous rocks. On Eagle River, and between it and Grand Rivers, beds of sandstone and limestone variously colored, and in the upper parts gypsiferous, afforded the plants *Calamites Suckovii*, *C. gigas*, *Stigmaria ficoides;* and Lesquereux concludes, since *C. gigas* has not been found below the Permian, that the beds are probably *Permian*. From the lower part of the series, Dr. Hayden has reported species of *Productus*, *Spirifer*, and from the upper, an *Orbicula*. Dr. Peale calls the beds *Permo-Carboniferous*. Mr. Marvine observed the beds passing down into the Carboniferous.

The question as to the age of the Lignitic beds is well discussed by Dr. Peale; and in the course of this discussion a full tabular list is given of all papers on the subject hitherto published, their places of publication, and the views they present, the several regions of the beds being taken up in succession.

The conclusions are:

That the Lignitic beds of Coalville and Bear River are undoubtedly *Cretaceous:* whether the Evanston should be included is left doubtful.

That the Judith beds are *Cretaceous*, and have their equivalent along the eastern edge of the Mountains (Front Range) below the Lignitic or Fort Union group, and also in Wyoming, and are, either, part of No. 5 (Fox Hills Group) of the Cretaceous, or, a group to be called No. 6.

That the coal (which is partly anthracite) of Rock Creek, Slate Creek, Anthracite Creek and Ohio Creek, is probably all of Cretaceous age. The coal of some beds is excellent, two analyses giving 88·2 and 91·9 p. c. of carbon. The anthracitic character is owing to a trachytic eruption.

That the Fort Union group (at Fort Union, Fort Clark, and under the White River beds, on the North fork of the Platte River, above Fort Laramie and west of Wind R. Mts., also on Grand River, Nebraska and farther north) and the Bitter Creek series (including beds of Black Buttes, Hallville, Medicine Bow, Carbon, Point of Rocks, the Rock Spring series and Washakie Station) are, although both afford Dinosaurian remains, *Lower Eocene.*

That the Lignitic beds east of the mountains in Colorado are the equivalent of the Fort Union group of the Upper Missouri, and are *Eocene;* "also that the lower part of the group, at least at the locality 200 miles east of Greeley, is the equivalent of a part of the Lignitic strata of Wyoming." The Lignitic beds near Golden, Denver, Colorado Springs, Cañon City, Raton Hills, are placed in a table with those of the Fort Union group; but are not afterwards remarked upon.

13. *Age of Angiospermous plants referred to the Cretaceous.*—In my notice of a paper by DeCandolle, on pp. 447–449 of this volume, I remark that the "Cretaceous plants of the United States are the plants of beds which had previously been determined, through the animal fossils, to be Cretaceous." This statement needs, as I find, some modification. It is a fact that the plant-bearing beds of the Lower Cretaceous of New Jersey and the Rocky Mountain region have been referred to the Cretaceous for stratigraphical reasons; and those of New Jersey on this ground, long before the plants were found. But the *chief* evidence in favor of this reference in the Rocky Mountain region was, as I learn from Dr. F. V. Hayden, who has been prominent in collecting the facts, the *existence of Angiospermous leaves*, the animal fossils

having been found in the layers just above those containing the leaves instead of those below. Further we have to admit that the stratigraphical evidence is far from demonstrating in either region that the plant-bearing beds are not Upper Jurassic. DeCandolle's charge is hence not far from right, and should be set aside, if possible, by further observations. Looking over Dr. Hayden's Report for 1874 (noticed above) I find that the Lignitic of the Dakota group (Lowest Cretaceous) is stated by Dr. Peale to have been observed at the mouth of the Gunnison to be *underlaid* by beds which contain a Cretaceous *Scaphite*, and Mr. Peale also mentions that Dr. Newberry speaks of the Cretaceous *Gryphea Pitcheri* being associated with the lower Lignitic beds of the same period. These appear to be pertinent facts. But more are needed. J. D. D.

14. *Swiss Paleontological Society.*—This society was founded in 1874, upon the plan of the Paleontographical Society, for the purpose of publishing the paleontological works of its members, especially those concerning Switzerland, and also of continuing, in a slightly different form, Pictet's *Matériaux pour la Paléontologie Suisse.* The volume for 1875 has just been distributed. It includes the second part of a monograph of *Pholadomya*, with 14 plates, by C. Mœsch; descriptions of Jurassic fossils from Savoy, and remarks upon their vertical distribution, with 7 plates, by E. Favre; further contributions toward distinguishing the Horses of the Quaternary, with 3 plates, by E. Rütimeyer; description of a lower jaw of *Dinotherium Bavaricum*, with 1 plate, by Is. Bachmann; description of Tertiary Echinoderms of Switzerland, with 8 plates, by P. de Loriol. The volume for 1874 contained the first part of Mœsch's monograph of *Pholadomya*, with 26 plates, and a description of fossil plants from Sumatra, with 3 plates, by O. Heer. The society announces, as in preparation, several papers upon fossil Mollusks, Crinoids, Echinoids, Nummulites, Ammonites, Turtles, Stags, etc. The work deserves better support than it has yet received. Only six American names are upon the list of members. The annual subscription is 25 francs, payable in advance to Prof. Eugene Renevier, Lausanne, Canton de Vaud, Switzerland.

15. *Geological Survey of New Jersey.*—Annual Report of the State Geologist, Prof. G. H. Cook, for the year 1875. 42 pp. 8vo. Trenton, N. J., 1875.—This report is mainly economical in its facts. It is accompanied by a large map showing the triangulations of the U. S. Coast Survey, including the primary stations selected in 1875.

16. *Eocene Corals of Italy.*—The memoir of Prof. d'Archiardi, of Pisa, on the Eocene corals of Friuli, has been issued as a separate work. It contains 100 pages of text, in 8vo, (describing a large number of species,) and 16 beautiful lithographic plates. The deposits of Friuli, as described by Prof. Taramelli, are a marly limestone containing echinoderms, and, below this, beds of

different kinds containing the fossil corals. The species are more than 120 in number and many of them are published as new. They show that the Italian seas in Eocene time were within the limits of the coral-reef seas.

17. *Physikalische Krystallographie und Einleitung in die krystallographische Kenntniss der wichtigeren Substanzen;* von P. Groth. 528 pp. 8vo. Leipzig, 1876.—Professor Groth of Strassbourg has done excellent service for the science of mineralogy by putting in the hands of students a clear and comprehensive work upon Physical Crystallography. He takes up first the general subject of wave-movements and the undulatory theory of light, and by a series of careful descriptions, aided by excellent illustrations, makes the whole subject very intelligible without the use of mathematical formulæ. The fundamental laws of light are then explained, and, as following from them, the various optical properties of crystallized minerals; the whole being treated in a thorough and comprehensive manner. The properties of crystals in their relation to heat, electricity, and magnetism, are also fully described. The second part of the work embraces a discussion of the forms of crystals, based especially upon the general laws of symmetry which characterize the different systems. The illustrations throughout the work are of a high degree of excellence: this is especially true of the colored plates at the end of the volume. A special chapter is devoted to the description of the various instruments employed in optical researches, and a considerable number of detailed examples are given. E. S. D.

III. Zoology.

1. *Recent Corals from Tilibiche, Peru, nearly* 3000 *feet above the sea-level.*—Professor A. Agassiz, in his recent South American tour, found a coral limestone at Tilibiche, 2,900 to 3,000 feet in elevation, about 20 miles in a straight line from the Pacific. The ravine where it occurs is about 450 feet below the general level of the nitrate basin of Peru. Two species of corals, modern in aspect, are described by L. F. Pourtalès, both new species, *Isophyllia duplicata*, and *Convexastræa ? Peruviana*, and besides these a Millepore was observed near *M. alcicornis*. Professor Agassiz concludes that the Pacific, within comparatively recent times, extended through gaps in the Coast Range and made an internal sea, which stood at a height of not less than 2,900 feet, and probably much above this, as the sea must have played an important part in the deposition of the salt and the nitrates of the nitrate beds; and consequently, that there has been an elevation since the formation of the coral reefs, of not less than 2,900 feet. The presence of other extensive saline basins at a height of 7,000 feet seem to make the submergence still greater. The existence of eight species of *Allorchestes* (Amphipod Crustaceans), a salt-water genus, in Lake

Titicaca, is stated to suggest the presence of the sea, at no very distant period, at a height of 12,500 feet.—*Bull. Comp. Zool.*, iii.

The facts have a special interest from the fact that there are now no coral reefs on the South American Coast south of Cape Blanco, near the equator, owing to the cold oceanic currents of the coast. The Coast Range would have been a protection against those currents in the era of the Tilibiche coral reefs.

2. *Caspian Sea.*—The zoology of the Caspian Sea has recently been studied by Mr. Oscar Grimm, with important results. He has found in this great half-salt lake 120 animal species, and states that the whole number existing there must exceed 150 species. His discoveries include 6 new species of fish, (a *Gobius* and five *Benthophili*), 20 species of Mollusks, (*Rissoa dimidiata*, *Hydrobia Caspia*, *H. spica*, *H. stagnalis* with two varieties, *Eulima conus*, *Neritina liturata*, *Lithoglyphus Caspius*, *Bythinia Eichwaldi*, *Planorbis Eichwaldi*, sp. n., *Cardium edule* and var. *rusticum*, *C. Caspium*, *C. crassum*, *C. Trigonoides*, *Adacna vitrea*, *A. edentula*, *A. plicata*, *A. læviuscula*, *Dreissena polymorpha*, *D. Caspia*, *D. rostriformis*, and some other terrestrial and fluviatile Mollusca), a Bryozoan (*Bowerbankia densa* Farre, in which the colonial nervous system may be admirably seen), and about 35 species of Crustacea, among which we find the family Gammaridæ in particular represented by colossal forms and *Idothea entomon* in considerable quantities. Then there are 20 species of worms (*Sabellides octocirrata*), numerous Turbellaria, two sponges (*Reniera flava*, sp. n., or perhaps a variety of *R. alba* O. Schm., and another *Reniera* in the larval state), and, lastly, 13 Protozoa, among which are 6 new species.

The most interesting gatherings were made at 108 fathoms. At one haul the dredge brought up 350 specimens of Gammarids, belonging to 4 or 5 species, 150 specimens of *Idotea entomon*, 50 *Mysids* of colossal dimensions, 6 fishes, a multitude of large specimens of *Hydrobia Caspia*, *Dreissena rostriformis*, and enough more of zoological specimens to make four times this number.

Among the author's conclusions are the following. These species common to different seas, show the affinities of the Caspian Sea to the Aral Lake, the Black Sea, and the Arctic Ocean; but the affinities with the glacial sea seem to be more recent than those with the Black Sea; for in the latter certain species, such as the seals, *Coregonus leucichthys*, and others which are common to the Caspian and glacial seas, are wanting. We may suppose that in the Tertiary epoch there existed in Europe and in the neighboring parts of Asia a vast closed basin of fresh water. By an upheaval of the crust of the earth, due to the action of internal forces which still make themselves felt energetically in the region of the Caspian, this was separated into some smaller basins, which are the existing Black Sea and the Aralo-Caspian basin. The latter in its turn was afterward divided, just as we still see, into two small salt lakes separate from the Caspian. At the same time the

water of the glacial sea penetrated into the basin of the Caspian, which still had a slight connexion with the Black Sea, so that only a small number of animals could arrive there from the glacial sea. Hence we find that the primitive forms of the Caspian are fresh-water animals (*e. g. Dreissena polymorpha*), and then that the emigrants from the glacial sea which reached it are marine animals for the most part inhabiting great depths. Hence, also, we recognize that the Caspian in its fauna presents more affinities with the glacial than with the Black Sea, which, again, has become richer in animals under the influence of the Mediterranean.

The Caspian has not only received species from the glacial sea, but has also furnished it with some—as, for example, a species of sturgeon, which seems to be *Acipenser ruthenus*, and lives in the rivers of Siberia. I regard the Sturgeons as belonging to the ancient Aralo-Caspian basin, and as having emigrated, as has been said, into the glacial sea, and perhaps even to America, where, as is well known, the nearest relatives of the *Scaphirhynchi* of the Aral exist. On the other hand we may presume that the place of origin of the Acipenseridæ was the Indian Ocean, and that they were derived from the Selachia, with which, especially when young, they have many points in common (*e. g.* their teeth).—*Zeitschr. wiss. Zool.*, xxv, 322, 1875, condensed from *Ann. Mag. Nat. Hist.*, IV, xvii, 176, Feb. 1876.

IV. Astronomy.

1. *Il passaggio di Venere sul Sole, osservato a Muddapur nel Bengala*; Relazione di P. Tacchini. Palermo, 1875.—The party of observers under P. Tacchini were provided with five telescopes two of which had spectroscopes. In this volume we have the results of their observations. P. Tacchini concludes, that the spectroscope can be employed to advantage in transits; that the solar diameter is smaller in the spectroscope than in an ordinary telescope; that the atmosphere of Venus so appears in the spectroscope as to show that it has a large quantity of vapor like the earth's atmosphere.

2. *Planets recently discovered.*—In the August number of the Journal for 1875, p. 158, was given a table of the recently discovered small planets. We here continue it, repeating some of the planets whose elements were then not well determined. In that table the names Siwa and Polana were interchanged, also the value of φ for Aethra should have been 22° instead of 2°. The elements below so far as (147) are obtained from the Berlin Astronomische Jahrbuch for 1878.

The name of (139), the planet discovered by Prof. Watson while at Peking, is Jue-wa, written in Chinese by two characters, but in western languages to be written without a hyphen, as in the table.

PLANETS RECENTLY DISCOVERED.

No.	Name.	Time of Discovery.	Discoverer.	Mean dist.	Angle of Eccent.		Incl.		Long. of node.		Long. per.	
					°	′	°	′	°	′	°	′
136	Austria,	Mar. 18, 1874.	Palisa.	2·2870	4	52	9	33	186	10	316	32
137	Meliboea,	Apr. 21, "	Palisa.	3·1334	12	2	13	46	204	18	310	20
138	Tolosa,	May 19, "	Perrotin.	2·4437	9	6	3	14	54	55	311	23
139	Juewa,	Oct. 10, "	Watson.	2·8140	2	57	8	19	358	37	115	32
140	Siwa,	Oct. 13, "	Palisa.	2·7316	12	29	3	12	107	2	300	33
141	Lumen,	Jan. 13, 1875.	Paul Henry.	2·7095	12	54	11	33	319	3	22	38
142	Polana,	Jan. 28, "	Palisa.	2·3872	6	3	2	18	292	36	227	23
143	Adria,	Feb. 23, "	Palisa.	2·7525	2	49	11	32	333	45	223	20
144	Vibilia,	June 3, "	Peters.	2·6501	13	29	4	52	76	50	8	21
145	Adeona,	June 3, "	Peters.	2·6939	12	17	14	24	77	43	118	8
146	Lucina,	June 8, "	Borelly.	2·7077	3	51	12	42	84	22	237	43
147	Protogeneia	July 10, "	Schulhof.	3·1254	1	42	1	57	252	29	84	43
148	Gallia,	Aug. 7, "	Pros. Henry.	2·7687	10	44	25	18	145	8	36	13
149		Sept. 21, "	Perrotin.									
150		Oct. 18, "	Watson.	2·9807	7	30	2	9	207	33	352	45
151	Abundantia	Nov. 1, "	Palisa.	2·5841	5	44	7	52	40	2	215	57
152	Atala,	Nov. 2, "	Paul Henry.	3·1320	4	43	12	10	41	29	80	0
153	Hilda,	Nov. 2, "	Palisa.	3·9504	9	23	7	51	228	20	284	42
154	Bertha,	Nov. 4, "	Pros. Henry.	3·2285	5	45	20	49	37	36	168	41
155		Nov. 8, "	Palisa.									
156	Xantippe,	Nov. 22, "	Palisa.	3·0375	15	17	7	29	246	11	155	57
157	Dejanira,	Dec. 1. "	Borelly.	2·5857	12	42	11	50	62	25	109	12
158	Koronis,	Jan. 4, 1876.	Knorre.	2·9901	16	59	1	23	282	49	355	10
159	Aemilia,	Jan. 26, "	Paul Henry.									
160	Una,	Feb. 20, "	Peters.	2·7334	3	28	3	51	9	18	56	49
161		Apr. 16, "	Watson.									
162		Apr. 21, "	Pros. Henry.									
163		Apr. 26, "	Perrotin.									

H. A. N.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Atti della Reale Accademia dei Lincei.* Serie 2, vols. 1, 2, 3. 4to, 1873–1876. Roma, 1875, 1876.—The "Accademia dei Lincei" held its first meeting near the beginning of the seventeenth century, and hence it is the oldest of existing scientific academies.* It has had, however, an intermittent existence, owing to the stifling conditions about it.

Founded by Federico Cesi, of the Roman nobility, in 1603, avowedly to promote the progress of truth, its members, and especially their leader, encountered almost immediate persecution; and in 1606 they were forced to suspend their sessions in order to escape greater evils. The Academy was at work again in 1609, and soon after, Galileo (then 45 years old), Baptista Porta and Colonna were among its members. The Academy adopted as its insignia the figure of a lynx—the piercing sight attributed from

* It was preceded in Italy, by the Academia Secretorum Naturæ, which was established by Baptista Porta, in 1560, and suppressed after a few years of existence by Pope Paul III.

ancient time to the lynx making it a fit emblem of the searching spirit of Science, of which Galileo was already an illustrious exponent. The members were "Lincei." They required that a candidate for membership should not be younger than 22 years or older than 30; and he must be devoted to the sciences of experiment or observation. Discussions in jurisprudence, modern history, theology, politics and poetry were excluded, because not properly within their range. The Academy had, in part, in conformity to the spirit of the place and times, the form of a religious order; for St. John the Evangelist was recognized as its protector, and the members were required to recite daily "l'officio della Beata Vergine." This, however, was not enough to save the "Lincei" from suspicion.

In 1630, Federico Cesi, the founder and patron of the Academy, died, to the grief and great loss of its members. The Academy had already come into disfavor, because Federico in 1625 had denied that the sky was solid, and Galileo had asserted that the earth moved; and, soon after Federico's decease, its sessions were for the *second* time, suspended. Some private meetings were occasionally held, under the protection of Cardinal Barberini, nephew of the pope, Urban VIII, at the house of Cassiano del Pozzo, where there was a rich museum. But in 1651, on the death of this Cardinal, the suspension became complete, and the Academy was for the second time dead; and so it remained for nearly a century.

Its revivification—the *second*—did not take place until 1740, when the learned and liberal Pope Benedict XIV, Lambertini, reinstated it and gave it the name of the "Accademia de' nuovi Lincei." But in 1758, on the death of this pope, it became for the *third* time extinct.

In 1795, a society of young men which had held meetings for scientific purposes since 1786 at the "Collegeis Umbro-Fuccioli" and which embraced among its members Feliciano Scarpellini, took the form of an academy, called the "Accademia Umbro-Fuccioli," which was in effect a revival—the *third*—of the old Academy. Owing to the political disturbances of 1801, the Academy was again suppressed. But in July, Pius VII, a patron of science and art, succeeded to the papal chair, and the meetings were resumed, Scarpellini having the full confidence and support of the pope. This was the *fourth* return to active life. It took at first the title of "Accademia Gaetani;" but in 1802 it adopted that of "Accademia de' nuovi Lincei," and in 1804, returned to the original name, dropping the *nuovi*.

The Academy continued in activity for forty years, sustained largely through the influence and labors of Scarpellini. With Scarpellini's death, in 1840, it became once more defunct, having been closed by Gregory XVI, against earnest solicitations. This pope finally gone, Pius IX succeeded; and being eminently liberal in his views when he took the pontificate, the Academy, a year

afterward, in 1847, was reëstablished for the *fifth* time, the Pope giving it the modified title "Accademia Pontificia de' nuovi Lincei."*

Finally, Rome having emerged from the dynasty of the popes, and become the Capitol of United Italy, under Victor Emmanuel, an extraordinary session was held in January, 1874, for the revision of the constitution. Among the changes, there was, first, the restoration of the original name "Accademia dei Lincei" with the addition of the prefix "Reale," recognizing the new government under which it existed. Next, the Academy was divided into two sections; one, of Physical, Mathematical and Natural Science, and the other of Moral, Historical and Philological Science; the former to consist of *forty* National Associates, *ten* Foreign Associates, and *sixty* Correspondents; and the latter of the same, excepting that the number of National Associates was made *thirty*. Eight foreign associates of the first section have been since elected; three residing in Great Britain, three in Germany, one in France, and one in the United States.

Of the *Atti* of the Academy, a second series was commenced in 1873, and three volumes have been published; vol. I. for 1873–1874; II. for 1874–1875, and III. for 1875–1876. They contain papers on Mathematical or Mathematico-physical subjects, by Volpicelli, Bataglini, Betti, Dini, Conti, Favero, Ascoli, Valentino, Cremona, Menabrea, Tonelli; in Solar Astronomy and Spectroscopy, by Respighi and Volpicelli; in Electricity by Govi, Ricco, and Volpicelli; in Chemistry by Cannizaro and Paternò; in Zoology, by Cadet, Maggiorani, Boll, Colasanti, De Sanctis, Moriggia, and Todaro, (the paper of the last an elaborate discussion of the anatomy of the Salpa with 10 4to plates; in Paleontology by Gastaldi, Capellini, Meneghini and G. Ponzi; on Volcanoes of Lazio, by G. Ponzi; on some Fungi Uredinei, by C. Bagnis Calor; in Meteorology, at the observatory of Campidoglio, by L. Respighi, and on the climate of Rome, by R. Paveto; Archæological discoveries about Rome by R. Canevari and others. Many of the articles are illustrated by plates.

Signor Cav. QUINTINO SELLA is now President of the Academy.

2. *Statistics of Mines and Mining in the States and Territories west of the Rocky Mountains;* being the Seventh Annual Report of ROSSITER W. RAYMOND, U. S. Commissioner of Mining Statistics. 540 pp. 8vo. Washington, 1875.—This volume brings the subject down to the close of the year 1874. The condition of mining industry in California, Nevada, Idaho, Oregon, Montana, Utah, Colorado and Arizona, is given in about 400 pages, forming Part I, full of interesting details and accurate information gleaned with care from many sources, and states with great condensation often in tabular form, and arranged for easy reference. Part II is devoted to metallurgical processes—its Progress in the west

* The preceding historical facts are taken from an address to the Academy delivered in March, 1848, by Volpicelli, on the occasion of this last reinstatement. Only two preliminary meetings had been held in 1847.

during 1874; the distillation of zinc-silver alloy; silver-lead smelting at the Winnamuck Smelting Works; the Germania Refining and desilverization works, Utah; the construction and operation of a slag hearth; the Rocky Mountain Coal and Coke, condensed from a paper by Mr. Blodgett Britton; separation of gray copper ore from barytes; the Patchen process. Part III treats of the geology of the Sierra Nevada in its relation to vein mining, by Amos Bowman, and his detailed observations will be read with profit by all who are interested in the genesis of veins however they may differ from some of the theoretical views of the author. This is followed by a history of the relative values of gold and silver, by R. W. Raymond, and another on improvements in mining and milling machinery in the Pacific States, by William P. Blake, with a description of the remarkable Silver Mill of the Consolidated Virginia on the "Big Bonanza" of the Comstock Lode in Nevada, and miscellaneous statistics.

We regret to state that unless some new action is had on the part of the General Government this is the last of the valuable series of Reports on the mineral resources of the United States which will appear.

3. *The National Academy of Sciences* held its regular annual meeting on April 18 to 21, at Washington City. The following are the titles of the papers read:

On the precise determination of the number of vibrations of tuning-forks, and on the effect of temperature and of amplitude of vibration on the vibratory periods of forks; by A. M. Mayer.

On a method of exploring the acoustic condition of the atmosphere, leading to the invention of an instrument for determining the direction of a source of sound; by A. M. Mayer.

On the sensations produced by concurrent sounds, and by sounds quickly succeeding one another; by A. M. Mayer.

On the theory of simultaneous ignition of many mines; by H. L. Abbot.

On Maxima and Minima in Algebra, by the late Gen'l D. P. Woodbury, with a biographical notice of the author; by J. G. Barnard.

The Character of the Eocene Fauna of New Mexico; by E. D. Cope.

Contributions to Meteorology; by E. Loomis.

A conjectural restoration of a pueblo of the Mound Builders; by L. H. Morgan.

The Geological evidence on the question of the cause of the cold of the Ice Period; by J. S. Newberry.

On the history of the Problem of the Tangencies; by B. Alvord.

On the theory of Magic Squares; by F. A. P. Barnard.

On the progress of a Magnetic Survey of the United States, at the charge of the Bache Fund of the Academy; by J. E. Hilgard.

Results of Experiments on Contact-resistance; by Wm. A. Norton.

On the imperfections of the present system of Chemical Nomenclature; by R. E. Rogers.

The Age of Mountains as determined by degradation; by J. W. Powell.

Biographical Memoir of Joseph Winlock, late Director of the Harvard Observatory, Member of the Academy; by Joseph Lovering.

On the Geological and Physical structure of the Black Hills; by Henry Newton.

4. *Memoir of Caroline Herschel*, by Mrs. John Herschel, with portraits. New York: D. Appleton & Co. 1876. 12mo, pp. 355.—The scientific life of Caroline Herschel as an observer and investigator in astronomy closed in 1822 with the death of her illustrious brother, William Herschel, with whom she was so

closely identified as to make the two lives almost one. She was already 72 years of age when she returned to Hanover, as she then believed soon to die. Her memoir is intensely individual. During her twenty-six years of exile in Hanover (1822 to 1848) from all those most loved in England, she maintained an active correspondence with her nephew, Sir John F. W. Herschel and his wife, and exchanged frequent letters with most of the eminent astronomers of the time in Europe. These letters, as well as parts of her diary and personal recollections, are excellent reading. We find in them much to compensate us for the want of productiveness, which Miss Herschel constantly laments as the great mistake of her life in not continuing in England; for if she had remained there this correspondence, so full of vitality and varied interest, would not have existed. While she was "minding the heavens" with her beloved "Sweeper," as of old, she would have found no time to record her recollections of her fifty years activity in her brother's service, to honor whom she was so willing to obscure her own real merits. But she will not be forgotten while scientific literature endures. We are led to hope that from the materials accumulated by her assiduity and other sources in the possession of the family of Sir John Herschel, we may yet have a satisfactory biography of Sir William Herschel—a work still wanting. B. S.

5. *The depth of the Pacific, and the nature of its bed.*—We take the following facts from a recent report by Prof. Wyville Thomson.

Between Hawaii and Tahiti, the depth, with one exception of 1,525 fathoms, ranged between 2,000 and 3,000 fathoms and has a mean of 2,600; the bottom, except near the islands, mainly red clay, with much oxide of manganese in small concretions, and many foraminifers; and over two patches, there were siliceous shells of Radolarians, making a "Radolarian ooze." The fauna of the bottom was very meager.

Between Tahiti and Valparaiso (reached on the 19th of October), 5,000 miles in distance, the course taken was southward to latitude 40° S., and then on that parallel to Valparaiso. The mean depth was 2,139 fathoms; the bottom was of red clay with nodules of manganese, with Globigerina ooze in the shallower parts. Life was very sparse, except between Juan Vernandez and Valparaiso, where, although the depth was 2,225 fathoms, it was abundant; the bottom was a bluish mud with very little manganese.

Notices of the following works are deferred to another number.

Reliquiæ Aquitanicæ, Part xvii, the closing part of the work. Williams & Norgate, London.

Geological Survey of Pennsylvania. Historical sketch of Geological explorations and other States, by J. P. Lesley. pp. 200 and xxvi, 8vo.

Mines and Mineral Statistics of N. S. Wales, 1875. 246 pp. with maps and sections.

Revue de Géologie pour les Années, 1873 et 1874, par M. Delesse et M. de Lapparent. Paris, 1876.

Geology for Students and General Readers. Part I, Physical Geography, by A. H. Green, M.A., F.G.S. 552 pp. 8vo. London. (Daldy, Isbister & Co.)

Second Annual Report of the Geological and Agricultural Survey of Texas, by S. B. Buckley, A.M., Ph.D., State Geologist. 96 pp. 8vo. Houston, Texas, 1876.

APPENDIX.

Art. LXVII.—*Notice of a new Sub-order of Pterosauria;* by Professor O. C. Marsh.

The first Pterodactyle discovered in this country was found by the writer, in 1870, in the Upper Cretaceous of Kansas; and during the next year two other species were obtained in the same region.* These three species were referred provisionally by the writer to the genus *Pterodactylus* of Cuvier, with which the remains then described essentially agreed. An examination of the large series of specimens of this order now in the Yale Museum, shows, however, that some of these fossils possess characters widely different from all forms known in the old world, and indicate a new and highly interesting type. The distinctive feature in this group is the *absence of teeth*, and hence the order may be called *Pteranodontia*, and the family *Pteranodontidæ*, from the typical genus described below.

Pteranodon, gen. nov.

This genus is readily distinguished from any Pterodactyles hitherto described by the cranial characters, which are well shown in a nearly perfect skull, and portions of others, in the Yale Museum. The cranium preserved is very large, and the facial portion greatly elongated. There is a high sagittal crest, which projects backward some distance beyond the occipital condyle. The latter is directed backward, and somewhat downward. The quadrate is long, and inclined well forward. The orbits are large, as are also the antorbital and nasal apertures. The maxillary bones are closely coossified with the premaxillary, and the whole forms a long, slender beak, which, in the specimens examined, tapers gradually to the pointed apex. There are no teeth, or sockets for teeth, in any part of the upper jaws, and the premaxillary shows some indications of having been encased in a horny covering. The lower jaws, also, are long and pointed in front, and entirely edentulous. The rami are closely united by a symphysis which extends from the apex to beyond the posterior extremity of the dentary bone, thus resembling the mandible of *Rhynchops* and some other birds. In several other respects, the jaws in this genus are more like those of birds than of any known reptiles.

The vertebræ in the present genus are similar to those in European Pterosaurians, and the altas and axis are united.

* This Journal, vol. i, p. 472, 1871; vol. iii, pp. 241 and 374, 1872.

There are four phalanges in the wing finger, and the metacarpal that supports it is longer than one half the ante-brachium. In one specimen, which probably belongs to this genus, there are four slender bones, apparently all metacarpals, which are pointed above, and do not reach the carpus. Another specimen, which is described below, and probably belongs to this genus, has five vertebræ in the sacrum.

The nearly complete skull mentioned above may be regarded as the type of the genus *Pteranodon*. Its principal measurements are as follows:

Length from occipital crest to end of premaxillary about 30 inches, or	760· mm.
Transverse diameter of occipital condyle,	8·4
Distance from occipital condyle to distal end of quadrate,	105·
Length of lower jaw about 23 inches, or	584·
Greatest depth,	62·2
Depth at articulation for quadrate,	23·2

The species represented by this specimen is well marked, and may be called *Pteranodon longiceps*. It is somewhat larger than *P. occidentalis* Marsh, which apparently has more slender jaws. The Yale collection contains portions of a skull indicating a much larger species, which is probably *P. ingens* Marsh. If this skull was of the same proportions as that just described, its length would be no less than four feet!

One of the smallest American species yet found is represented in the Yale Museum by several bones of the wing, a number of vertebræ, and the nearly complete pelvis. The wing-bones preserved are elongated, and very slender. The pelvis is unusually small, and there are five vetebræ in the sacrum. The last of the series indicates that the tail was short. The following are the principal dimensions of this specimen:

Length of ulna,	187· mm.
Length of metacarpal of wing finger,	300·
Antero-posterior diameter of outer condyle at distal end,	15·
Transverse diameter of shaft, above condyles,	13.
Length of first phalanx of wing finger,	347.
Extent of five vertebræ of sacrum,	57.

This species, which may be called *Pteranodon gracilis*, was about two-thirds the size of *P. velox* Marsh. It probably measured about ten feet between the tips of the expanded wings.

All the specimens here mentioned are from the Upper Cretaceous of Western Kansas. It is an interesting fact that the localities and geological horizon of these specialized, toothless, Pterodactyles are precisely the same as those of the *Odontornithes*, or birds with teeth, and the two doubtless lived together in the same region.

Yale College, New Haven, May 15, 1876.

Pteranodon comptus, sp. nov.

The smallest Pterodactyle known from American strata is indicated by portions of three skeletons in the Yale Museum. Among these remains are two distal ends of the characteristic metacarpal of the wing finger, other portions of the wing bones, and two sacral vertebræ. The large metacarpal is very slender, and elongated, and its outer distal condyle has its superior margin elevated above the shaft, and terminated proximally in a point. The ulna is comparatively large, and the proximal carpal has an oval air cavity on its radial side. The sacral vertebræ have their centra short, and medially constricted.

The principal measurements of the remains of this species are as follows:

Greatest diameter of ulna at distal end,	15· mm.
Transverse diameter of proximal carpal,	17·
Antero-posterior diameter of outer distal condyle of wing metacarpal,	12·8
Longitudinal extent of condyle,	11·6
Transverse diameter of shaft above condyle,	11·5
Length of medial sacral vertebra,	9·0
Transverse diameter of centrum,	8·4

The above specimens are all from the Upper Cretaceous of Western Kansas.

Yale College, May 22, 1876.

ART. LXVIII.—*Notice of new Odontornithes*; by Professor O. C. MARSH.

AMONG the remains of Cretaceous Birds in the Yale Museum, are specimens which indicate two undescribed species of special interest. Both were of gigantic size, and clearly belong to the *Hesperornithidæ*, although quite distinct from *Hesperornis regalis* Marsh, the type of the group.* The more important characters of each, so far as now known, are given in the following description:

Lestornis crassipes, gen. et sp. nov.

The present genus is very nearly related to *Hesperornis*, but the sternum has five pits on each side for the attachment of ribs, and essentially no posterior emarginations. The tarso-metatarsal bones present a distinctive feature which may prove of generic value. On the inner side of the upper half of each, there is a large tuberosity, somewhat similar to the ossified

* This Journal, vol. iii, p. 360, 1872, and vol. x, p. 403, 1875.

support of a rudimentary spur. The teeth and the vertebræ in this genus resemble closely those of *Hesperornis*.

The present species is based upon the greater part of a skeleton, including portions of the skull. These remains indicate a huge swimming bird, fully six feet in length, from the apex of the bill to the end of the toes, or somewhat larger than *Hesperornis regalis*. The femur and the tibia resemble those in some modern diving birds, but the toes are shorter and stouter. The large rugosity on the metatarsal bone is a striking character, which may possibly be an indication of sex. The sutures uniting the three metatarsals are well marked.

The principal dimensions of this specimen are as follows:

Length of sternum,	197· mm.
Width in front,	162·
Extent of five articulations for ribs,	54·
Length of femur,	103·
Transverse diameter of distal end,	51·
Transverse diameter of tibia at distal end,	33·
Length of tarso-metatarsal,	135·
Transverse diameter of proximal end,	35·5
Transverse diameter through protuberance,	30·5
Length of first phalanx of fourth toe,	39·5

The known remains of this species are from the Upper Cretaceous deposits of Western Kansas.

Hesperornis gracilis, sp. nov.

A second species of *Hesperornis*, somewhat smaller than *H. regalis*, and of more slender proportions, is indicated by a few remains in the Yale collection. The most characteristic of these specimens is a left tarso-metatarsal, which in general form is very similar to the corresponding bone in *H. regalis*, but is much less robust. The following are its principal measurements:—

Length (approximate) of tarso-metatarsal,	130· mm.
Transverse diameter of proximal end,	29·
Antero-posterior diameter,	17·
Distance from proximal end to articulation for hallux,	78·
Transverse diameter of shaft at articulation for hallux,	15·1
Antero-posterior diameter,	18·
Antero-posterior diameter of distal condyle of third metatarsal,	14·
Transverse diameter,	7·

This species, also, is from the Upper Cretaceous of Western Kansas.

Yale College, New Haven, May 18, 1876.

Ichthyornis victor, sp. nov.

In addition to the remains described above, the Yale Museum contains a number of specimens which indicate a new species, apparently, of the genus *Ichthyornis*. The best preserved of these fossils consist of characteristic portions of the humerus, coracoid and scapula, all parts of one skeleton. They pertain to a bird somewhat larger than a pigeon, and about one-third larger than *Ichthyornis dispar* Marsh, the type of the order *Odontotormæ*.* The humerus has the radial crest greatly expanded, indicating strong power of flight. The radial condyle of the distal end is larger than that for the ulna. The coracoid is stout, and at its scapular articulation has a nearly round, deep pit, into which was inserted a corresponding tubercle of the scapula, forming a strong support for the humerus. Above this tubercle, the scapula has an anterior angle, sharp and pointed.

The remains preserved of this species have the following dimensions:—

Greatest diameter of distal end of humerus,	12·5 mm.
Longitudinal extent of radial condyle,	6·
Diameter of shaft just above condyle,	10·
Greatest diameter of coracoid at articulation with scapula,	6·5
Diameter of articular pit,	3·
Extent of coracoid above top of pit,	8·
Vertical diameter of scapula at articulation,	8·
Transverse diameter,	3·

The known remains of this species are from the same region and geological horizon as those above described.

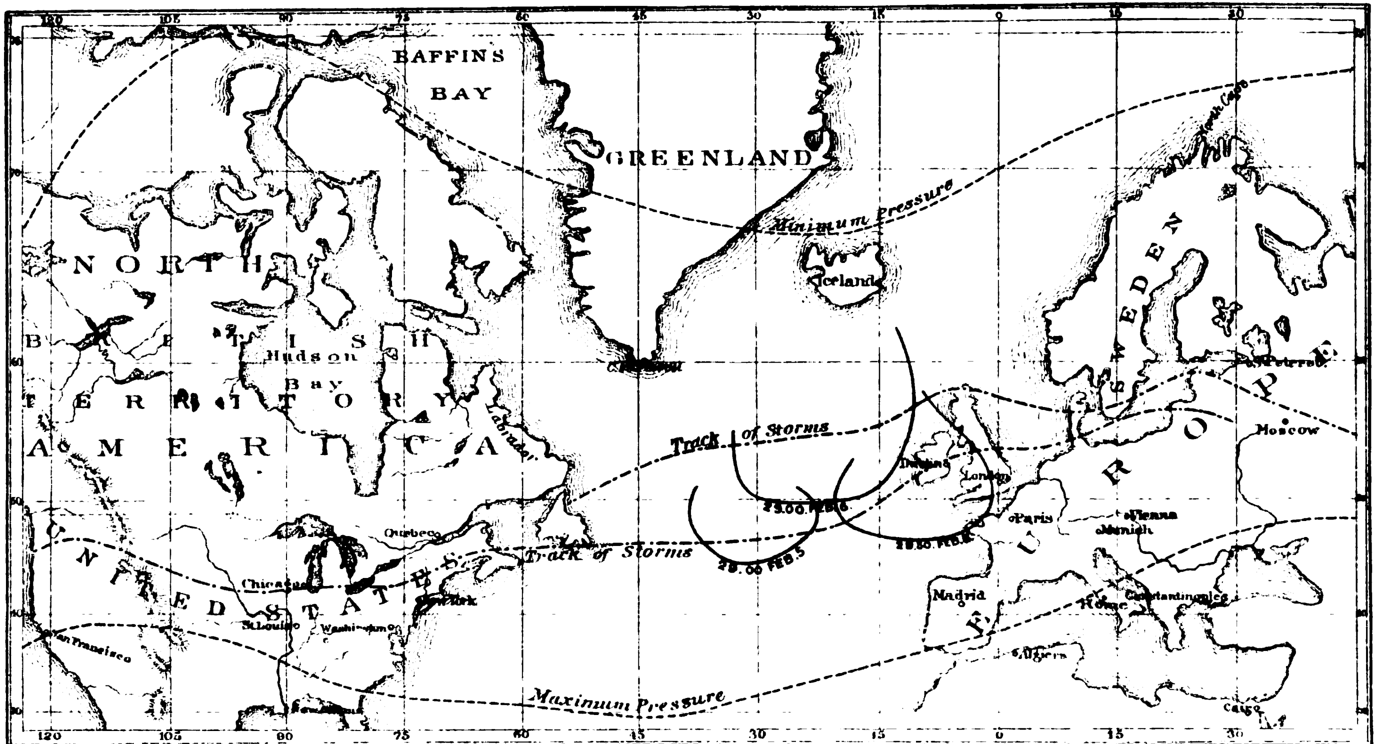
Yale College, May 22, 1876.

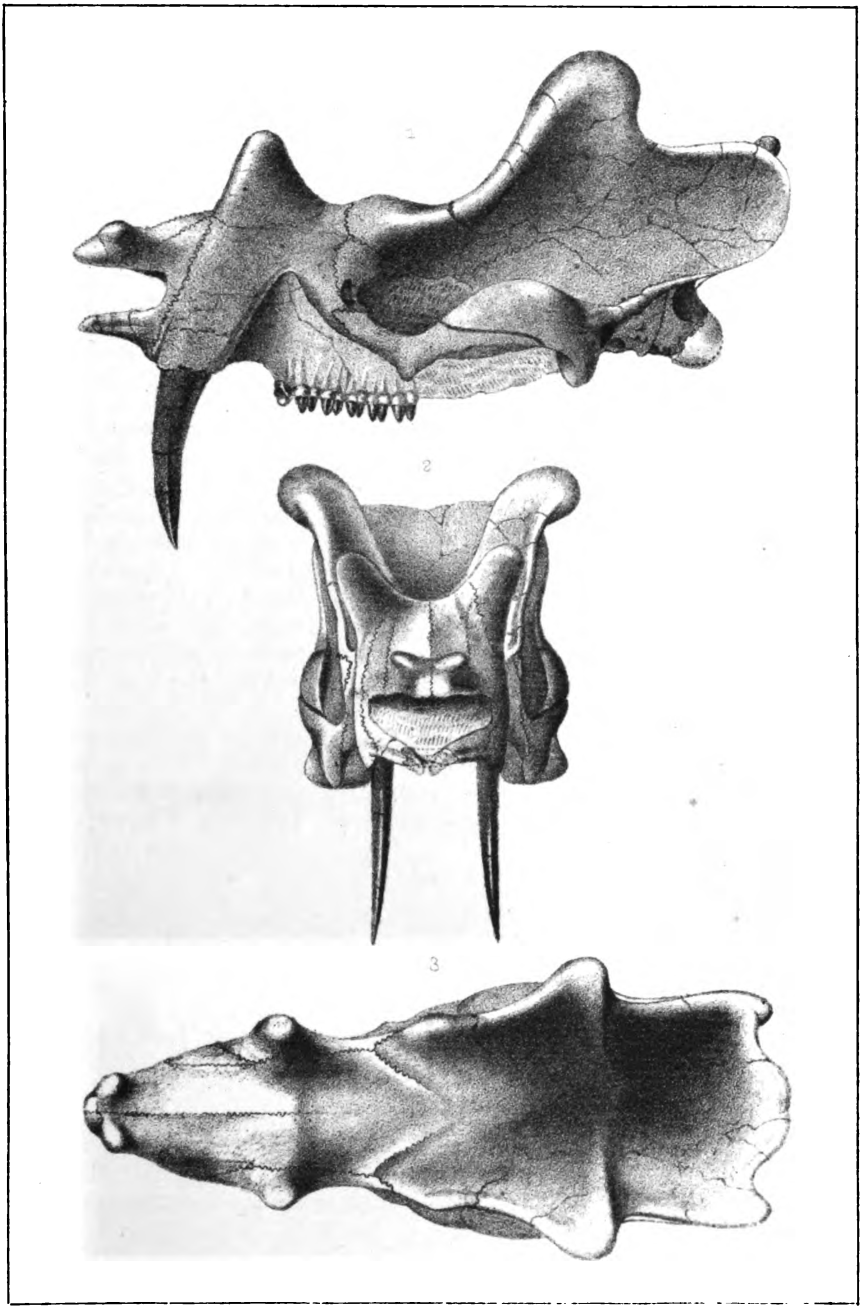
* American Naturalist, Vol. IX, p. 630, Dec., 1875. This name was substituted for *Ichthyornithes*, which proved to be preoccupied.

INDEX TO VOLUME XI.*

* The Index contains the general heads BOTANY, GEOLOGY, MINERALOGY, ZOOLOGY, and under each the titles of Articles referring thereto are collected.

STORM OF FEB. 5-8 1870. PLATE 1.





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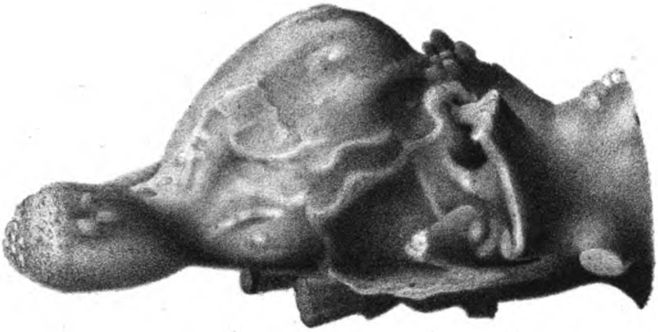

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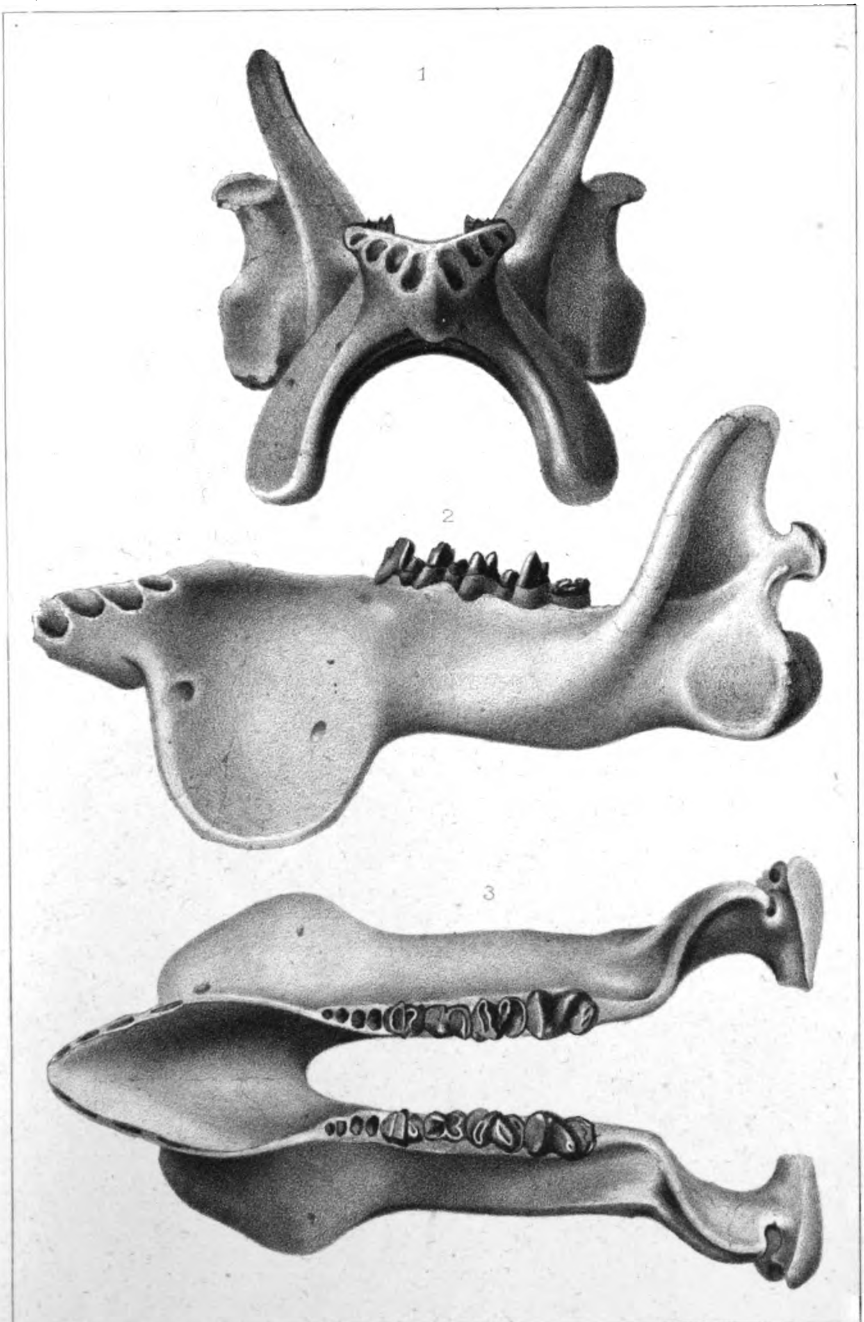
DINOCERAS MIRABILE, Marsh ½



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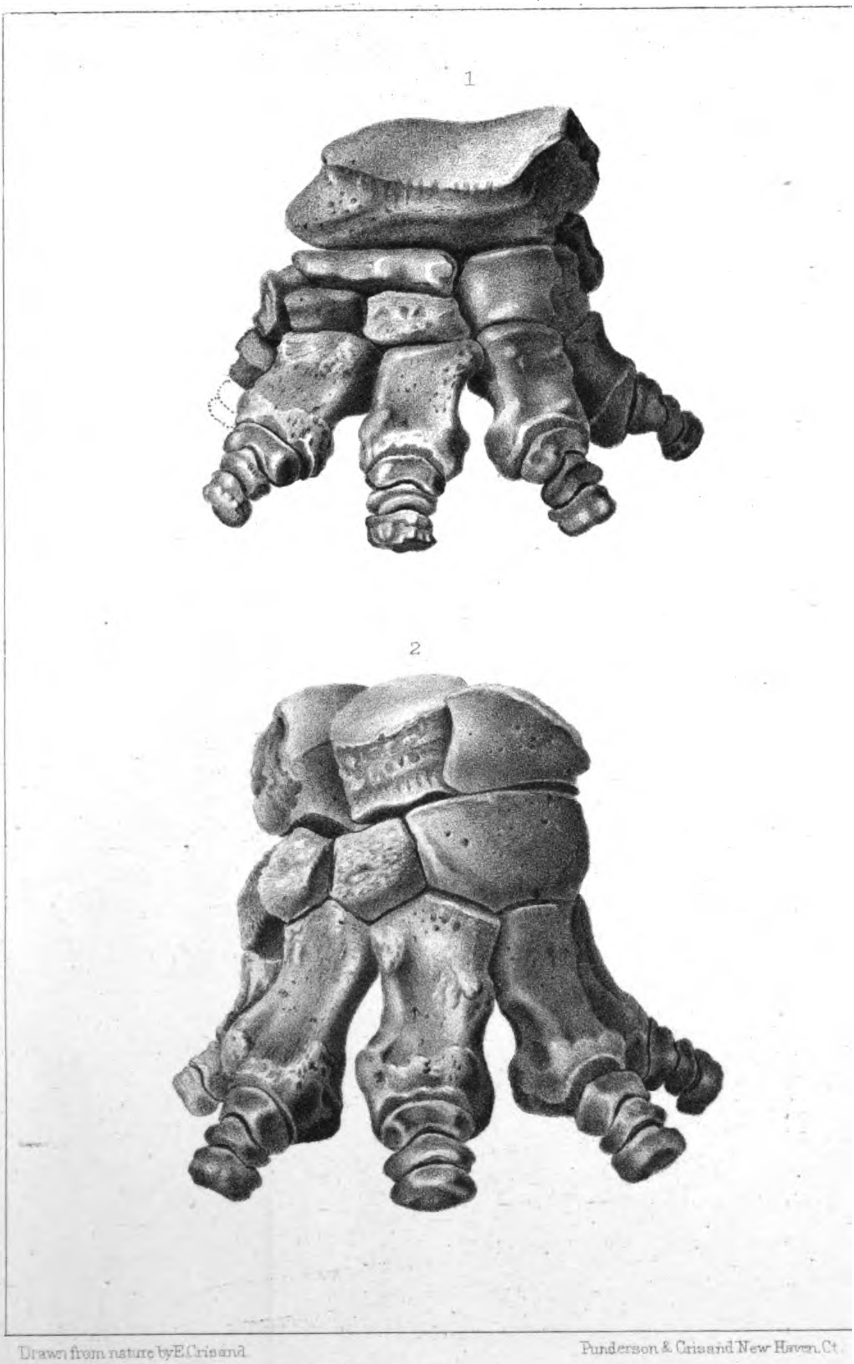
DINOCERAS LATICEPS. Marsh 1/5



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DINOCERAS ⅓

PLATE VIII

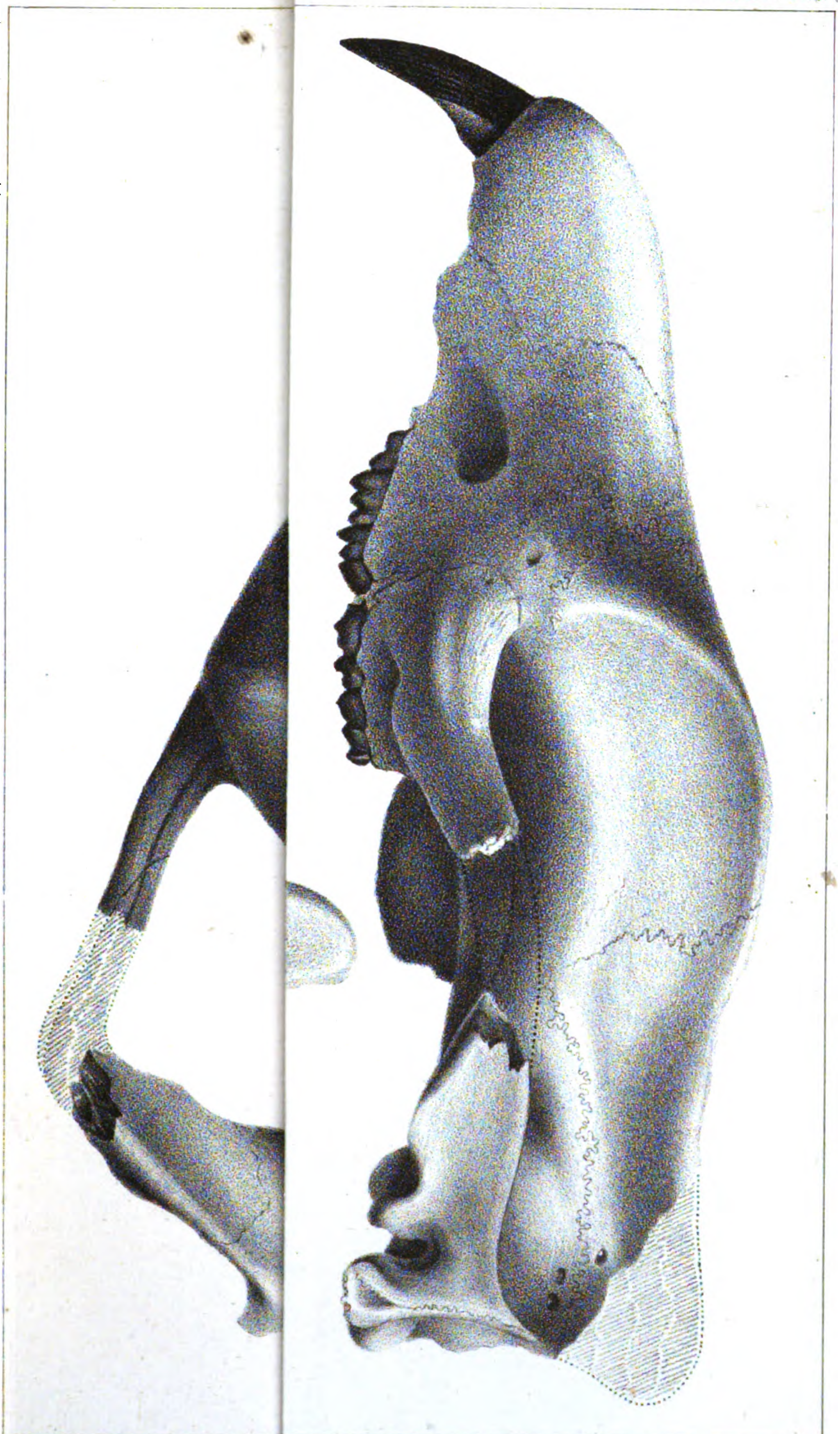
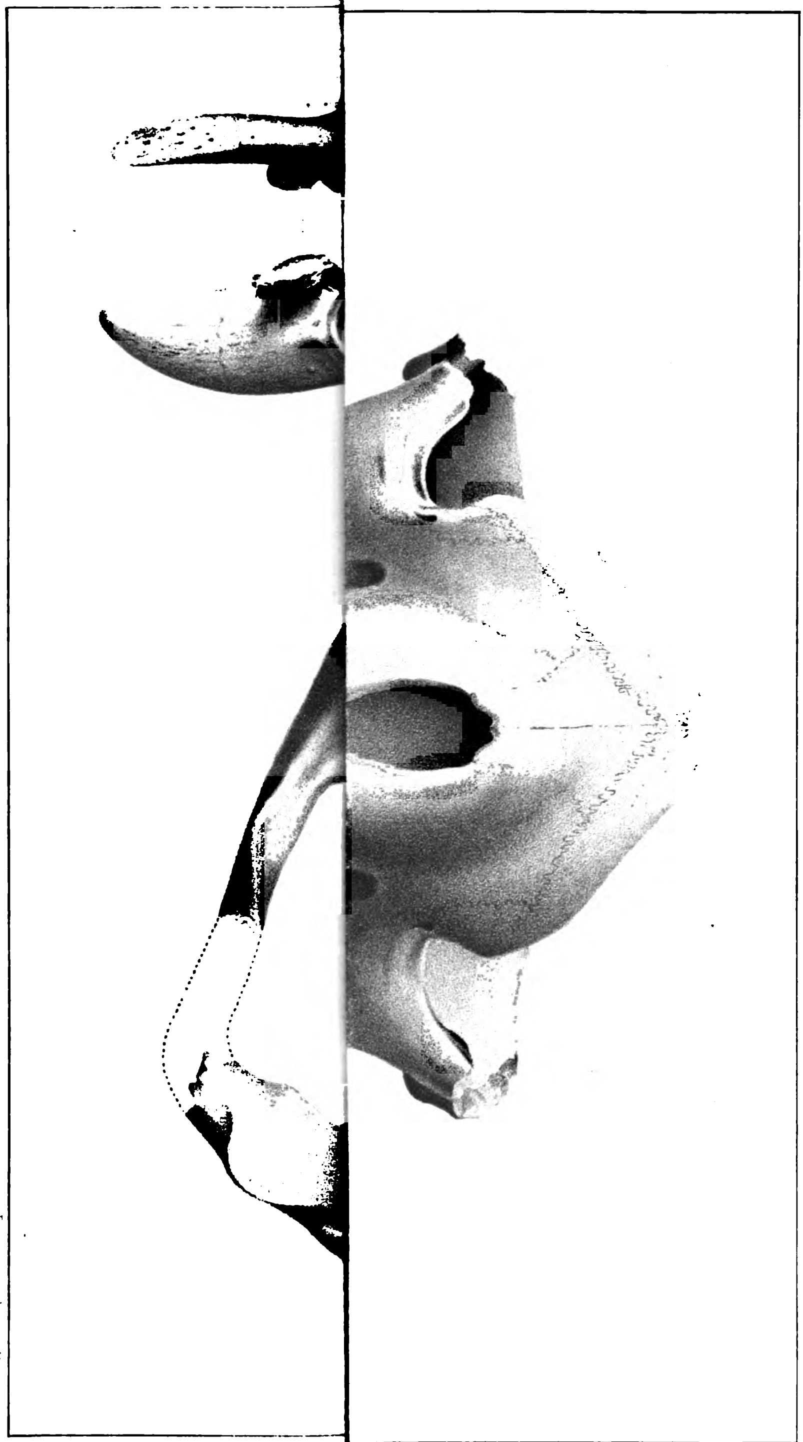
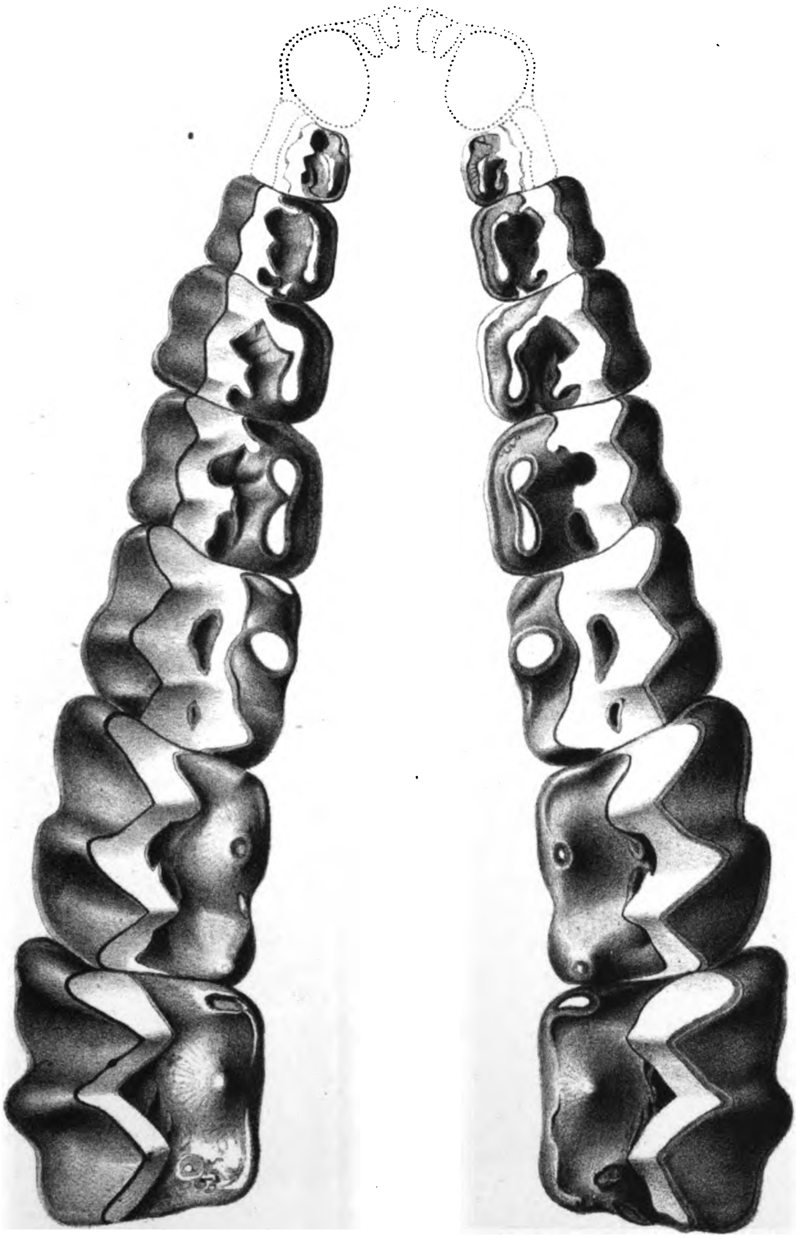


PLATE IX





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BRONTOTHERIUM INGENS, Marsh.

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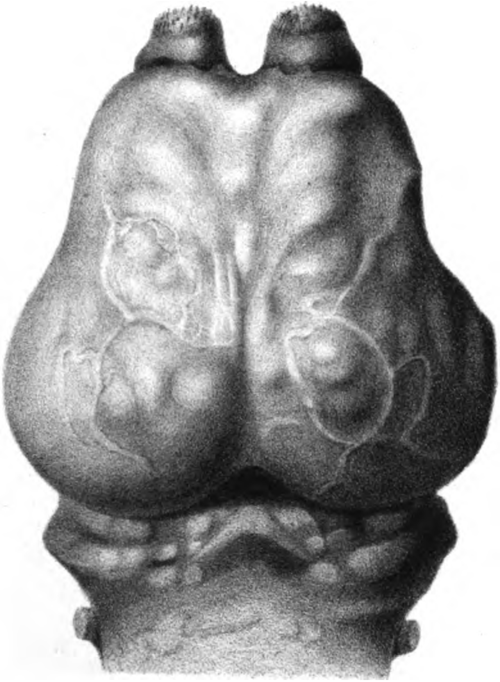

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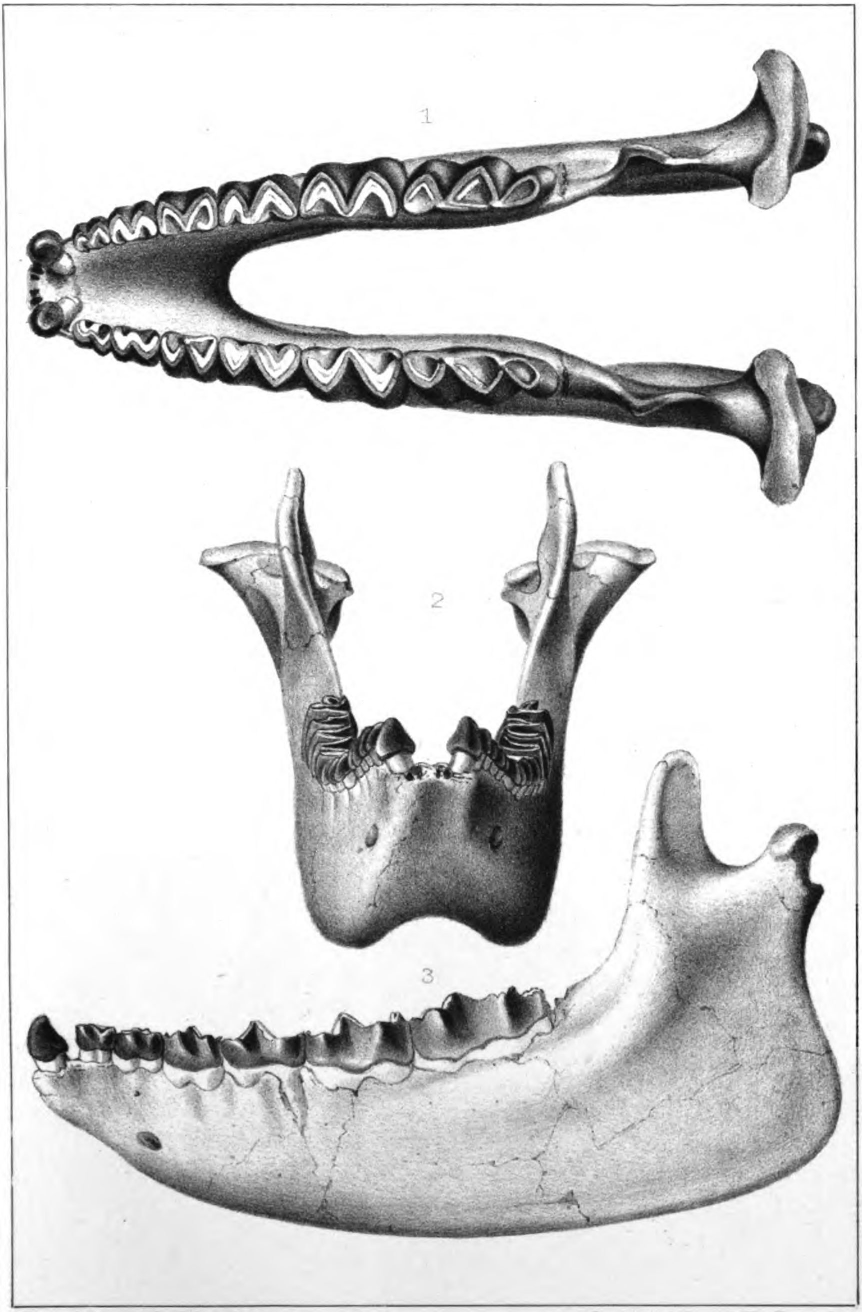

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BRONTOTHERIUM GIGAS. Marsh ⅙.

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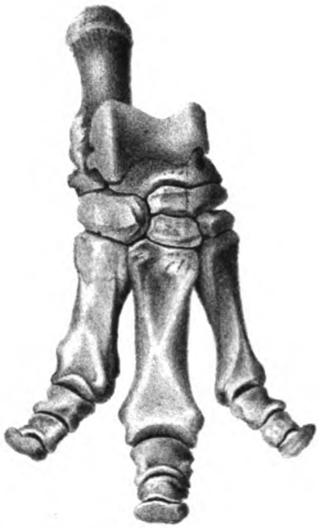

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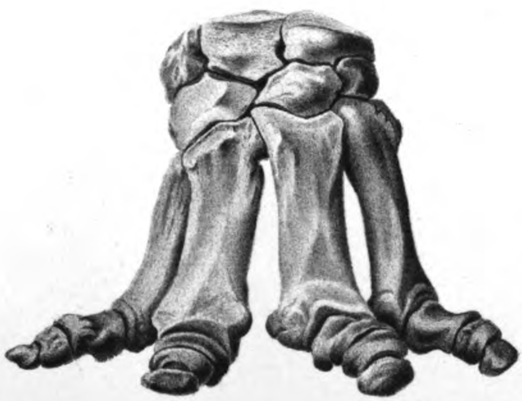

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BRONTOTHERIUM ⅙.

THE

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THIRD SERIES.

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CONTENTS OF VOLUME XII.

NUMBER LXVII.

NUMBER LXVIII.

SCIENTIFIC INTELLIGENCE.

NUMBER LXIX.

NUMBER LXX.

SCIENTIFIC INTELLIGENCE.

NUMBER LXXI.

SCIENTIFIC INTELLIGENCE.

NUMBER LXXII.

ERRATA.—On page 459, 20th line from foot, for *Amherst*, read *Andover*.

THE

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[THIRD SERIES.]

ART. I.—*Contributions to Meteorology, being Results derived from an examination of the Observations of the United States Signal Service, and from other sources;* by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Fifth paper. With plates I and II.

[Read before the National Academy of Sciences, Washington, April 19, 1876.]

Low temperature of December, 1872.

IN my second paper (this Jour., vol. ix, p. 8) I called attention to the unusually low temperature of the latter part of the month of December, 1872. At that time I had little information upon this subject except what could be derived from the daily weather maps, and these were unsatisfactory because the telegraphic reports had failed from a large number of the most important stations. As the observations of the Signal Service have since been published in full, the phenomena of that period can now be discussed more satisfactorily.

The temperature of December, 1872, in the United States, was not remarkably low until about the middle of the month. On the morning of December 16th the sky was overcast from Lake Michigan to Lake Ontario, and there were indications of the formation of an area of low barometer in that vicinity. At this time there was an area of high barometer central over Dakota, where the highest pressure was 30·51, and there was a cold area nearly concentric with it, the greatest depression being 25° below the mean temperature of December. By 4 P. M. an area of low barometer was developed which was central over Buffalo (bar. 29·77), accompanied by light snow and rain, and at 11 P. M. this area had reached the Atlantic coast.

On the morning of the 17th the high pressure from Dakota

had moved southeastward and was central over Cincinnati (bar. 30·44). The temperature throughout this vicinity was 15° below the mean of December. At the same time another center of high pressure appeared near the northern line of Dakota, where the barometer was 30·39, and temperature 25° below the mean. On the morning of the 18th the pressure in Dakota had risen to 30·64, with a temperature 44° below the mean. During the 18th this area of high barometer stretched out towards the southeast, and on the morning of the 19th this high pressure extended, like a ridge, from the north line of Dakota to the Atlantic coast near Cape May, where the pressure was 30·52. The greatest depression of temperature was, however, west of Lake Huron, from which region the cold area extended to the Rocky Mountains. At the same time a storm, proceeding from Texas, advanced towards the northeast, and on the morning of the 20th was central over Lake Ontario (bar. 29·43). By this storm the high pressure of the 19th was crowded towards the northeast, and the temperature rose throughout the storm area; but at the same time a new area of high barometer formed in Dakota (bar. 30·37), and the thermometer sunk 34° below the mean. During the 20th this area of high pressure moved southward, and on the morning of the 21st its center was near lat. 42°; and the pressure had increased to 30·72. The cold had now become very intense, and extended over a vast area, the greatest depression being 41° below the mean, and the area of 30° depression stretched from the Rocky Mountains to Lake Michigan, a distance of 1,500 miles. It extended southward to lat. 38°, and northward beyond the limits of the United States.

On the morning of the 22d an area of low barometer formed near the Rocky Mountains, in Wyoming (bar. 29·60), and the area of high barometer was crowded towards the southeast, being now central over Cincinnati (bar. 30·65). The cold area had increased greatly in extent, advancing southward and eastward. It was most intense at Port Stanley, on Lake Erie, where the depression was 44°; but the area of 20° depression extended from the Gulf of Mexico to Canada, and from New York city westward to long. 97°.

The storm of the 22d advanced eastward, and on the morning of the 23d was central over Lake Huron. At the same time an area of high barometer formed in Dakota and Minnesota (bar. 30·60) accompanied by a very low temperature. At La Crosse the depression was 39° below the mean, and the area of 20° depression extended from Lake Huron to the Rocky Mountains, and from lat. 37° on the south to British America on the north.

On the 23d a storm center appeared in Oregon, and on the morning of the 24th the barometer at Portland, Oregon, stood at 29·15. By this storm, the area of high pressure and of low

temperature, on the east side of the Rocky Mountains, was crowded eastward. On the morning of the 24th the highest pressure was at La Crosse 30·85, and the area of 30·40 pressure extended from long. 100° to New York, and from lat. 34° on the south to British America on the north. On Plate I. are shown the isobars for this date, for each tenth of an inch variation of pressure. The greatest depression of the thermometer was at St. Louis, 45° below the mean, and the area of 20° depression extended from the Gulf of Mexico to British America, and from long. 102° to Nova Scotia. On Plate II. are drawn curves, at intervals of 5°, showing how much the temperature at each place was above or below the mean temperature of December.

On the morning of the 25th the Oregon storm had crossed the Rocky Mountains, and had crowded the high pressure of the 24th still further eastward. The pressure was now greatest over Lake Ontario, 30·66. The cold area still stretched from Texas to Nova Scotia, the depression being 42° on Lake Ontario, and 32° at Indianola, on the Gulf of Mexico. A storm was now organized over the eastern part of the Gulf of Mexico, accompanied with heavy rain in Florida and along the Atlantic coast, changing to snow as it advanced northward.

On the morning of the 26th the center of this storm was over the Atlantic Ocean near Norfolk, Va. (bar. 29·46). At the same time another area of high barometer had formed over Minnesota (30·92) accompanied by a depression of the thermometer of 31°. On the morning of the 27th this area of high pressure remained nearly unchanged in magnitude and position, but the depression of the thermometer at several places had increased to 37°. During the 27th the high pressure diminished in amount and moved towards the southeast. On the the morning of the 28th the center of high pressure was over Tennessee (30·61) and the greatest depression of the thermometer was 29°. Another storm center had already formed in the northwest, which reached the Mississippi valley on the morning of the 29th, and now at none of the stations west of the Mississippi did the depression of the thermometer exceed 16°.

The accompanying table exhibits the observed changes of temperature from Dec. 16 to Dec. 27. Column second shows the mean temperature of December at the stations named in column first, and the succeeding columns show the difference between the mean temperature of the month and the temperature observed each day at 7^h 35^m A. M. At this hour the temperature is about 4° below the mean temperature of the day, so that the numbers given in the table should all be increased by about 4° in order to show the depression below the mean temperature at the hour of observation. The depressions mentioned in the preceding description were all copied from this table.

Observations of the Thermometer at 7^h 35^m A. M., *Dec.*16–27, 1872.

STATIONS.	Mean temp. of Dec.	Above or below the mean Temperature.											
		Dec. 16.	Dec. 17.	Dec. 18.	Dec. 19.	Dec. 20.	Dec. 21.	Dec. 22.	Dec. 23.	Dec. 24.	Dec. 25.	Dec. 26.	Dec. 27.
Portland, Or.,	39°	− 7	− 6	− 5	− 5	0	− 6	+ 7	....	+12	+ 9	+ 9	+11
San Francisco,	52	− 9	−11	−11	−11	−10	− 6	− 9	− 3	+ 3	+ 8	+ 8	+ 1
San Diego,	55	−10	− 3	−12	− 9	−10	− 9	−12	− 5	0	0	0	+ 3
Corinne,	28	−12	− 6	− 1	−20	0	−22	+ 6	+ 7	+14	+ 8	+ 7	+ 7
Virginia City,	19	− 1	− 9	−20	−24	−19	−37	+11	−36	− 7	+14	+ 3	+13
Fort Benton,	11	− 5	−12	−44	−15	−18	−41	−11	−26	−14	−19	−22	−22
Santa Fe,	31	−11	−10	−17	−16	−17	− 8	−13	− 8	−10	+ 5	− 4	+ 4
Denver,	26	−14	−20	−19	−28	−15	−31	+14	−19	− 8	+19	+ 1	− 4
Cheyenne,	26	−19	−22	− 6	−33	−27	−33	+ 6	−32	0	+11	−11	+ 8
Fort Sully,	13	−18	− 6	−24	−27	−26	−38	−11	−36	−17	−13	−28	−14
Pembina,	−4	....	−25	−25	−21	−26	−31	−12	−30	−33	−10	−25	−33
Indianola,	54	−10	−11	− 5	− 7	−16	− 7	−22	− 8	−27	−32	−22	−31
Omaha,	20	−17	−12	−11	−19	−22	−36	− 9	−34	−32	−17	−26	−27
Breckenridge,	4	−20	−20	−32	−27	−34	−36	−14	−37	−25	−16	−31	−37
Leavenworth,	26	−15	−17	−15	−15	−29	−28	−15	−30	−39	−26	−30	−30
Galveston,	56	− 8	−12	− 4	+ 7	−12	−10	−21	− 7	−21	−29	−24	−30
Shreveport,	47	− 9	−10	− 9	−10	−17	−21	−27	− 5	−25	−30	−21	−32
St. Paul,	11	−16	− 6	−16	−25	−18	−30	−11	−34	−36	−15	−12	−28
Duluth,	11	−21	−14	−26	−29	−25	−33	−29	−37	−39	−12	−18	−22
Keokuk,	26	−16	−16	− 8	−22	−26	−27	−25	−32	−43	−30	−18	−37
La Crosse,	17	−25	−13	−17	−26	−28	−40	−29	−39	−44	−21	−11	−34
Vicksburg,	49	+ 8	−11	− 5	− 7	− 9	−17	−29	− 7	−21	−27	−23	−37
Davenport,	23	−11	−15	−10	−21	−19	−27	−27	−30	−40	−23	−12	−28
St. Louis,	31	− 8	−15	− 5	−11	−21	−24	−34	−23	−45	−34	−22	−29
Memphis,	39	− 6	−12	− 5	− 9	−14	−19	−29	−13	−34	−28	−19	−29
New Orleans,	55	+ 3	0	+10	+ 2	− 2	−13	−24	− 9	+ 2	−15	−21	−32
Cairo,	35	− 9	−16	− 7	− 7	−20	−18	−37	−13	−39	−29	−24	−27
Mobile,	51	+ 5	+ 1	+ 8	+ 3	+ 1	−17	−24	− 9	− 1	−13	−13	−33
Milwaukee,	21	− 7	−14	− 9	−24	−17	−31	−33	−34	−42	−17	− 4	− 6
Chicago,	24	− 5	−15	− 1	−25	−12	−24	−34	−32	−44	−17	− 6	−20
Marquette,	18	−17	−15	−21	−27	−12	−36	−38	−28	−32	−15	− 5	− 5
Escanaba,	16	−10	−16	−18	−26	−12	−36	−24	−34	−36	−16	− 8	− 4
Nashville,	39	+ 4	− 9	0	− 6	− 5	−18	−36	−14	−31	−19	−12	−27
Montgomery,	48	+ 7	+ 4	+15	+ 2	+ 2	−16	−27	−13	− 3	− 6	−10	−28
Grand Haven,	26	+ 6	− 5	− 7	−21	−11	−19	−30	−28	−36	−26	−15	− 6
Indianapolis,	30	− 6	−19	− 5	−12	− 7	−27	−39	−23	−41	−32	−17	−22
Louisville,	35	− 3	−13	− 2	− 6	− 7	−19	−29	−12	−35	−25	−15	−28
Cincinnati,	34	− 1	−14	− 6	− 6	− 4	−17	−36	−12	−33	−31	−15	−26
Knoxville,	38	+ 2	− 3	+ 2	− 3	+ 9	−11	−34	−19	−10	−10	− 5	−24
Toledo,	28	− 9	−15	− 4	−15	− 7	−23	−43	−19	−37	−22	−20	−23
Alpena,	23	−10	−14	−11	−18	− 1	−17	−36	−25	−33	−18	−18	−10
Detroit,	25	− 7	−13	− 3	− 9	− 4	−19	....	−15	−39	−19	−18	−20
Lake City,	52	− 4	+ 3	+11	+12	+15	0	−20	−19	− 4	+ 4	- 9	−24
Punta Rassa,	65	− 3	− 2	+ 1	0	+ 3	− 4	−13	−10	− 3	+ 2	+ 1	− 6
Augusta,	46	0	+ 6	+ 6	+ 2	+ 1	− 7	−20	−23	− 7	−16	−16	−22
Key West,	70	− 3	+ 1	+ 2	+ 2	+ 4	− 4	− 5	− 3	− 2	+ 4	+ 3	− 3
Jacksonville,	54	− 7	− 1	+ 7	+ 6	+12	0	−17	−17	− 7	+ 2	−10	−22
Cleveland,	28	− 6	−11	− 2	− 5	+ 4	−16	−40	−13	−29	−24	−13	−23
Saugeen,	28	− 4	+ 9	−10	−12	− 6	−12	−27	−20	−24	−27	−24	−28
Port Stanley,	28	−12	−15	− 7	−19	− 3	−20	−44	−16	−37	−23	−22	−22
Savannah,	50	− 4	+ 9	+13	+ 3	+11	− 1	−20	−11	− 8	− 4	−18	−25
Port Dover,	28	−11	−14	− 5	−15	− 3	−21	−41	−15	−37	−25	−21	−27

Table—continued.

STATIONS.	Mean temp. of Dec.	Above or below the mean Temperature.											
		Dec. 16.	Dec. 17.	Dec. 18.	Dec. 19.	Dec. 20.	Dec. 21.	Dec. 22.	Dec. 23.	Dec. 24.	Dec. 25.	Dec. 26.	Dec. 27.
Charleston, ...	49°	— 1	+ 9	+ 2	+ 1	+11	+ 1	—16	—12	— 4	—17	—16	—18
Pittsburg, ...	31	— 3	—13	— 5	—10	+14	—12	—36	—11	—30	—26	— 9	—22
Toronto, ...	23	— 8	—10	— 2	— 9	+ 9	—13	—33	—12	—28	—24	—24	—25
Lynchburg, ...	36	0	+ 2	— 4	— 4	— 3	— 8	—26	—16	—18	—26	—18	—21
Buffalo, ...	29	— 2	— 5	— 6	— 7	+ 9	—11	—30	—12	—27	—23	—14	—17
Wilmington, ...	46	0	....	— 3	— 3	+11	— 2	—15	—25	— 8	—19	—12	—12
Rochester, ...	25	— 3	— 6	— 9	+ 1	+11	—14	—32	—12	—24	—24	—22	—21
Washington, ...	35	— 2	— 3	— 5	— 7	+ 2	—10	—31	— 7	—27	—27	—20	—23
Baltimore, ...	35	— 1	0	— 4	— 1	+ 1	— 6	—27	— 7	—24	—21	—18	—20
Oswego, ...	28	— 4	— 2	— 6	— 1	+ 4	— 6	—20	—14	—20	—28	—21	—23
Kingston, ...	21	— 1	— 3	+ 4	— 4	0	— 6	—28	— 5	—38	—42	....	—27
Norfolk, ...	40	— 2	+ 1	0	— 5	+18	— 7	—17	—11	—18	—19	— 4	—19
Philadelphia, ..	33	— 3	— 2	— 3	— 2	+ 7	— 6	—27	— 9	—22	—28	—24	—24
Cape May, ...	34	+ 7	— 2	+ 2	— 4	+10	— 7	—22	— 4	—23	—22	— 3	—22
New York, ...	32	— 2	— 1	— 1	— 2	+ 6	— 3	—18	—14	—21	—24	—24	—20
Montreal, ...	16	+ 1	+ 5	+ 4	— 2	+ 3	— 3	— 9	—12	—26	—32	—29	—16
Burlington, ...	22	— 4	+ 5	— 5	— 1	+ 3	+ 1	—14	—18	—28	—36	—34	—24
New London, ..	29	— 7	— 1	— 7	— 5	+ 8	— 1	—15	— 8	—20	—26	—25	—21
Mt. Washington,	6	+ 1	+ 4	+ 1	— 6	— 1	— 4	— 5	—10	—25	—25	—10	+ 2
Quebec, ...	14	—11	+ 5	— 4	— 9	— 2	— 6	+ 1	—21	—28	—36	—34	—18
Boston, ...	28	— 7	— 1	— 5	— 2	+ 6	+ 3	— 9	—19	—19	—32	—26	—17
Portland, Me., .	23	—11	— 5	— 9	+ 1	+ 6	0	— 4	—19	—21	—40	—26	—12
Halifax, ...	25	— 9	— 1	—17	— 1	—11	+ 9	— 6	—17	—16	—30	—23	— 2

It will be observed that at the stations on the Pacific coast the depression was at no time greater than 12°; and at Corinne the only other station west of the Rocky Mountains the greatest depression was 22°. Hence it is obvious that the extreme cold experienced in Dakota *did not come from beyond the Rocky Mountains;* certainly not from any point south of lat. 49°. During the period in question, intense cold uniformly made its first appearance on the east side of the Rocky Mountains near long. 100°. It cannot be certainly decided from the observations, in what latitude the depression of the thermometer below the mean was greatest. The greatest observed depression was not always at the most northern station, which seems to indicate that there was a source of cold independent of the transfer of air from a higher to a lower latitude. When a cold area was once formed, it exhibited remarkable persistence both as respects its form and position. In its motion southward, it followed closely the eastern slope of the Rocky Mountains, and at one time a depression of 32° extended entirely across the United States from Canada to the Gulf of Mexico at Indianola; but at Charleston and Norfolk on the Atlantic coast the greatest depression was 24°; and generally at the eastern stations the

greatest depression was less than at western stations in the same latitude.

These results appear to explain the facts mentioned in my third paper (vol. x, p. 11) showing that a great diurnal change of temperature is most common at stations near the eastern slope of the Rocky Mountains. The cold wave makes its first appearance in this region and the intensity of the cold is sensibly diminished as the wave travels eastward. An example illustrating the variable climate of the eastern slope of the Rocky Mountains occurred Dec. 24, 1872. Denver was at that time on the borders of the cold area which prevailed from the Rocky Mountains to Nova Scotia, and during the night of the 23d and 24th the thermometer fell to 2°. During the 24th, Denver began to feel the influence of the storm which was advancing from Oregon, and on that day the thermometer rose to 55°, showing a change of 53° in a day, and probably the entire change took place in less than 24 hours. Similar cases must frequently occur near the eastern slope of the Rocky Mountains, and the changes of temperature are more sudden here than they are near the Atlantic coast, because the cold which succeeds a storm is more intense than it is in the eastern portions of the United States.

It will be noticed that from Dec. 23d to Dec. 27th, the depression of temperature on the summit of Mt. Washington (elevation 6,285 feet) was generally less than at other stations in its vicinity. On the 24th, the depression on the summit was about the same as near its base; but on the 26th the depression was *twenty degrees less* than near the base, indicating that at this time the vertical thickness of the cold stratum of air did not much exceed 9,000 feet.

The fluctuations of temperature observed from Dec. 16 to Dec. 27, 1872, were similar in their general features to those occurring every winter, but they were remarkable for the long continuance of an unusually low temperature. What was the cause of this protracted period of severe cold? It can scarcely be doubted that this low temperature was, at least, in part, due to causes in operation beyond the limits of the United States. It is noticeable that during this period the barometer was unusually high, and there was a general correspondence between the curves of high pressure and of low temperature. If then we can discover the cause of the high barometer, we shall probably find the explanation of the low temperature.

In my third paper (vol. x, p. 8) I gave a table showing the number of cases in which an area of high pressure was found on different sides of an area of low pressure during a period of three years. These numbers are as follows:

On the North side,	23 cases.		On the South side,	25 cases.	
" Northeast "	39	"	" Southwest "	20	"
" East "	90	"	" West "	37	"
" Southeast "	75	"	" Northwest "	19	"

It will be observed that an area of high barometer was found on the east side of an area of low barometer almost three times as frequently as on the west side; and it was found on the southeast side almost four times as frequently as on the southwest side. These numbers are to be understood as applying to the United States Weather Maps: that is, the centers of high and low pressure were restricted to a certain distance from each other, and the average distance was about 1200 miles. The prevalent direction is about 20° south of east; in other words, whenever an area of low barometer is formed in the United States, we may be tolerably sure that there exists at the same time an area of high barometer at a distance of about 1200 miles, and in a direction a little south of east.

In order to determine whether this coincidence was the result of local causes, I have examined Hoffmeyer's charts for the Atlantic Ocean and Europe and have found that an area of low barometer on the northern part of a chart, is almost invariably accompanied by an area of high barometer on the southern part of the same chart. In about three-fourths of the cases examined, the direction of the high pressure from the low is southeast, and the average distance is about 1700 miles. These results are derived from so large a number of cases that they cannot well be ascribed to accident, and seem to indicate the operation of a general law. They naturally suggest the idea that areas of high pressure are formed from the air which is expelled from areas of low pressure; and that in Europe as well as in the United States this forming process takes place chiefly on the southeast side of an area of low pressure. The comparisons which I have made also indicate that in Europe the direction of the high area from the low area is more southerly than it is in the United States, and the distance sensibly greater.

These conclusions may be tested in another way. Low barometer is generally associated with high temperature, and high barometer with low temperature. Hence we should conclude that a temperature above the mean in Iceland, would be accompanied by a temperature below the mean in Central Europe. For the purpose of comparison, I have taken the tables furnished by Prof. Dove in the Memoirs of the Berlin Academy. He has there given the mean temperature of Iceland for each month from 1823 to 1837, a period of fifteen years, and also the mean temperature of numerous stations in Europe for the same period. I selected all those months in which the

temperature at Iceland was at least one degree (Reaumur) above the mean, and placed opposite them in a table, the temperature of the corresponding months at Vienna, Berlin, Prague and numerous other stations scattered all over Europe. The number of months employed in this comparison was 50, and during this period the average temperature at Iceland was 2°·10 R. *above* the mean for the corresponding months. During the same months the temperature at Vienna was 0°·94 R. *below* the mean, showing between the two places a variation from the mean temperature amounting to 3°·04 R. or 6°·84 Fahr. If we restrict the comparison to the four months from November to February, the difference amounts to 8°·66 Fahr.

I then selected all those months in which the temperature of Vienna was at least one degree (Reaumur) *below* the mean and placed opposite to them the temperature at Iceland for the same period, and found that during the four coldest months of the year the result was of the same kind and quite as decided as in the former comparison; but during the warmer months the influence was less noticeable.

Similar differences, but not quite as great, were found to prevail throughout Austria and Germany, and the same influence in a diminished degree prevails in France, Italy and a large part of Russia. The period employed in this comparison seems to be long enough to establish a law, and I think we must conclude that when the temperature of Iceland is much *above* the mean, the temperature of Central Europe is generally depressed *below* the mean, and this influence is most decided during the colder months of the year.

The results thus obtained for the United States and for Europe suggest the idea that an area of unusually high barometer in the central portion of North America may be the result of a storm prevailing at a distance of 1500 or 2000 miles in a northwest direction. Upon referring to a map we find that the Aleutian Islands are situated in this direction, and at a distance of about 2000 miles from Oregon, and we know that in the neighborhood of these Islands the storms of winter are unusually severe and the barometer often sinks extremely low. If we had maps showing the isobaric curves from day to day in the vicinity of the Aleutian Islands, and extending to the central portions of North America, it is presumed we should find that low pressure near these Islands was generally attended by an area of high pressure in a southeast direction at a distance of 1500 or 2000 miles. The Report of the United States Signal Service for 1873 contains Meteorological observations at St. Paul's Island, lat. 57° N., long. 170° W., but I have no observations from the interior of British America suitable for comparison with them; it is, however, remarkable that in several cases

in 1872–3, when the barometer was unusually low at St. Paul, it was unusually high in Oregon or Dakota. The following is an example:

Date.	St. Paul.	Portland, Oregon.
1872, Nov. 13	29·92	30·52
" 14	29·40	30·55
" 15	29·07	30·60
" 16	29·08	30·51
" 17	29·43	30·52
" 18	28·68	30·64
" 19	28·62	30·58
" 20	28·98	30·56
" 21	29·38	30·40

During this period of nine days while the average pressure at St. Paul was 29·20, the average pressure at Portland, Oregon, was 30·50. Also from Dec. 15 to 26, 1872, the average pressure at Breckenridge, Minnesota, was 30·50, but during the same time the average pressure at St. Paul was 29·25; and Dec. 18, when the barometer at Breckenridge stood at 30·70, the barometer at St. Paul stood at 28·05.

Form of areas of maximum and minimum pressure.

In preceding articles (this Jour., vol. viii, p. 11, and vol. x, p. 9) I have shown the average form of the isobars about a storm center as derived from observations of three years. I have since made a similar comparison of observations of three years (1873–5) to determine the form of the isobars about an area of maximum pressure. The isobar selected has generally been that of 30·20; but when the observations were insufficient to show the complete form of this curve, I have taken the isobar 30·30, provided that curve was nearly complete. When both of these curves were incomplete I have taken the next highest curve whose form could be satisfactorily determined. The whole number of cases employed in these comparisons was 238. The longer axis of each of these isobars was measured, and also the axis perpendicular to the former, and the ratio of the two was determined. The average ratio of the two axes was found to be 1·91. In fifteen cases the major axis was at least three times the minor axis; and in two cases the major axis was at least four times the minor axis; the highest value being 4·6. In other words, the average form of the isobars about an area of maximum pressure is an oval whose major axis is nearly double the minor axis; and in six per cent of the cases the major axis is three times the minor axis, while in one per cent of the cases the major axis is four times the minor axis.

The average ratio of the two axes of the isobars about an area of minimum pressure was found to be 1·94; and in nearly four per cent of the cases the major axis was four times the minor axis.

The direction of the major axis of each curve was measured with a protractor, and reckoned in degrees from the north point toward the east. The following table shows the number of cases included in each interval of ten degrees. Column first shows the directions divided into intervals of ten degrees, and column second shows the number of cases occurring in each interval. In order to eliminate the influence of accidental causes, I have taken the average of each three successive numbers in column 2d, and have placed the result in column 3d. These numbers show a decided maximum corresponding to the direction N. 44° E. Column 4th shows the observations of the isobars about an area of minimum pressure as heretofore reported, and column 5th shows the averages of the same numbers taken in sets of three. These numbers also show a decided maximum corresponding to the direction N. 39° E.

The close agreement between the average form of the curves for high and low pressure, as well as in the prevalent direction of the major axis of the curve seems to indicate the operation of a constant cause. In order to determine whether this phenomenon is of a local nature, I have made a similar comparison of European observations. I took Hoffmeyer's charts from Dec., 1873, to Nov., 1874 and measured the form of the isobars about each storm center.

Position of the Major Axis of the Isobars.

DIRECTIONS.	UNITED STATES.				EUROPE.			
	High Barom.		Low Barom.		Low Barom.		High Barom.	
	Cases.	Aver.	Cases.	Aver.	Cases.	Aver.	Cases.	Aver.
0°– 10°	19	15	17	12	7	5	2	3
10 – 20	12	15	18	17	8	6	3	2
20 – 30	14	17	15	22	4	6	2	2
30 – 40	25	20	34	24	6	6	1	1
40 – 50	21	25	23	26	7	7	1	1
50 – 60	29	22	22	17	7	6	2	3
60 – 70	17	17	7	15	4	5	7	5
70 – 80	8	12	16	10	4	3	5	6
80 – 90	11	7	8	13	1	2	5	4
90 –100	3	5	14	10	1	1	2	4
100 –110	2	3	9	10	1	2	5	3
110 –120	5	4	7	6	3	2	3	4
120 –130	6	5	3	6	3	4	5	3
130 –140	5	7	7	6	5	4	1	3
140 –150	9	7	8	8	3	3	2	1
150 –160	6	8	8	8	2	2	1	1
160 –170	9	10	8	9	1	2	1	2
170 –180	14	15	10	12	3	4	3	2

Only those cases were selected which contained an isobar as low as 740 millimeters. The isobar selected for measurement was seldom the lowest isobar drawn on the maps, but the largest isobar which was complete (or nearly so) about the storm center. The number of cases employed was 70, and the average ratio of the two axes was 1·60. Column 6th in the preceding table shows the number of cases for each 10° of azimuth; and column 7th shows the averages of the same numbers taken in sets of three.

In a similar manner the isobars about areas of maximum pressure were measured. Only those cases were selected which contained an isobar as high as 775 millimeters, and frequently this was the isobar selected for measurement; but if the map showed a larger isobar which was complete, or nearly so, that was taken in preference. The number of cases employed was 51 and the average ratio of the two axes was 1·82. In the preceding table, column 8th shows the number of cases for each 10° of azimuth, and column 9th shows the averages of the same numbers taken in sets of three.

The following table presents a summary of the preceding results both for low and high pressures in the United States and Europe.

Summary of Results for Isobars.

	LOW BAROMETER.		HIGH BAROMETER.	
	United States.	Europe.	United States.	Europe.
Ratio of the two axes,	1·94	1·60	1·91	1·82
Prevalent direct. of major axis,	N. 39° E.	N. 31° E.	N. 44° E.	N. 76° E.

This table suggests some obvious reflections, but I prefer to withhold them until I have obtained a longer series of observations from Europe.

Relation of rainfall to variations of barometric pressure.

In former articles (this Jour., vol. viii, p. 4 and vol. x, p. 5) I have shown a close connection between the rain-fall and the direction and velocity of a storm's progress. I have also endeavored to determine (vol. viii, p. 11) by what indications it may be known whether the barometric pressure at the center of a storm is increasing or diminishing. Since receiving the published observations of the Signal Service for eleven months (Sept., 1872 to July, 1873) I have resumed this discussion and have discovered a decided connection between the amount of rain-fall and the pressure at the center of the storm. For the purpose of comparison, storms were divided into three classes; one class including those cases in which the barometric depression at the center of the storm was the same on two successive

days, or the change was less than 0·05 inch. A second class included those cases in which the pressure at the center *decreased* to the extent of at least 0·05 inch; and a third class included those cases in which the pressure *increased* to the extent of at least 0·05 inch. The following is the result of this comparison including 194 cases for eleven months of observations.

Influence of variations of barometric pressure.

				AMOUNT OF RAIN-FALL.		
	No. of cases.	Barom. at centre.	Variation in 24 hours.	Within isobar 29·90.	Within isobar 29·80.	Greatest fall.
Pressure increasing,	45	29·58	+·100	·069	·078	0·65
" stationary,	81	29·56	—·005	·120	·149	0·86
" decreasing,	68	29·48	—·128	·134	·159	1·02

Column 2d shows the number of cases of each of the three classes of storms investigated; column 3d shows the average pressure at the center of the storms under investigation; column 4th shows the average change of pressure at the center of the storm in twenty-four hours, + increasing, – diminishing; column 5th shows the average rain-fall for eight hours at all the stations included within the isobar 29·90; column 6th shows the average rain-fall at the stations within the isobar 29·80; and column 7th shows the average obtained by taking the greatest rain-fall reported for each storm at any of the stations. This greatest rain-fall generally occurred near the center of the storm-area.

These results clearly indicate that the amount of rain-fall is least when the pressure at the center of the storm is increasing, or the storm is diminishing in intensity; and the amount of rainfall is greatest when the pressure at the center of the storm is decreasing, or the storm is increasing in intensity; and we arrive at the same conclusions whether we take the average rain-fall at all the stations within the isobar 29·90; or confine ourselves to the stations within the isobar 29·80; or take simply the single station which reports the greatest rain-fall. This effect is most decided during the colder months of the year.

Stationary storms near the coast of Newfoundland.

In a former article (vol. xi, p. 17) I have noticed the fact that storms sometimes remain almost stationary for several days near Nova Scotia or Newfoundland. This phenomenon I ascribe to an unusual precipitation of vapor in that vicinity. The vapor is furnished by the warm water of the Gulf Stream, and the high-lands near the coast afford facilities for its precipitation. We should therefore expect to find the average rainfall in this vicinity to be unusually great. That such is the fact is shown by the following table which gives the annual

rain-fall at various stations along that part of the coast. For this table I am indebted to Mr. G. T. Kingston, Superintendent of the Meteorological Service of Canada.

Annual Rain-fall in Nova Scotia and its vicinity.

STATIONS.	Latitude.		Longitude.		Average rain-fall. Inches.	No. of years.
St. Johns,	47°	33′	52°	40′	55·86	4
Harbor Grace,	47	42	53	15	48·36	4
Bay St. George,	48	30	58	29	47·75	1
Glace Bay,	46	13	59	58	61·81	6
Sydney,	46	12	60	14	58·36	6
Cape North,	47	3	60	25	47·35	1
Port Hastings,	45	39	61	29	43·67	2
Guysborough,	45	23	61	36	60·40	3
Pictou,	45	42	62	40	50·58	2
Charlottetown,	46	14	63	10	41·90	3
Truro,	45	20	63	20	49·50	4
Seaforth,	44	38	63	34	47·87	2
Halifax,	44	40	63	36	51·29	11
Beaver Bank,	44	34	63	39	42·94	3
Windsor,	44	54	64	7	42·53	1
Dorchester,	45	46	64	18	48·53	4
Cape Rozier,	48	56	64	21	33·17	3
Wolfville,	45	5	64	25	41·88	8
Bass River,	46	30	65	12	38·21	5
Chatham,	47	1	65	30	44·48	2
Bathurst,	47	37	65	41	33·21	2
St. John,	45	14	66	5	54·68	9
Fredericton,	45	55	66	40	45·52	4
Quebec,	46	48	71	12	37·27	6

It will be noticed that near the southern coast of Nova Scotia and Newfoundland there is a line of stations where the annual rain-fall ranges from 50 to 60 inches, while at a distance of 200 or 300 miles from the coast, the annual rain-fall is less than 40 inches. Also if we follow along the coast of the United States as far south as Washington we find that scarcely any where does the average rain-fall exceed 45 inches. The precipitation on the south coast of Nova Scotia and Newfoundland is therefore excessive, and is sometimes sufficient to hold a storm nearly stationary for several days.

Course and velocity of storms in tropical regions.

In order to discover the causes of the movement of storm-areas, it is important to study their phenomena under the greatest possible variety of circumstances. For this purpose I have prepared a list of all the storms originating near the West India Islands, for which I have found definite paths assigned by any investigator. The principal results are exhibited in the following table. Column 1st shows the date of commencement of the storm so far as ascertained; column 2nd shows

the latitude of the storm's center when it first became violent; column 3d shows the average course of the storm while moving westward; column 4th shows the hourly velocity of progress in the preceding part of its course; column 5th shows the latitude at which the storm was moving due north; column 6th shows the average course of the storm after turning eastward until it reached the parallel of 40°; column 7th shows the hourly velocity of progress during the preceding period; column 8th shows whether rain was mentioned as accompanying the storm; column 9th indicates the name of the person by whom the phenomena of the storm were investigated; (R) stands for William Reid; (W) stands for William C. Redfield; (M) for Matthew F. Maury; (B) for Alexander Buchan; (E) for John R. Eastman; (T) for Henry Toynbee; and (S) for the U. S. Signal Service. Column 10th shows where the record of the investigation may be found.

It will be noticed that the least latitude of any storm-path here recorded is 10°; that is, over the Atlantic Ocean no storm-path has been traced within 10° of the equator. On Maury's storm chart for the North Atlantic (this Jour., vol. xi, p. 12) among 6436 observations, each observation representing a period of eight hours, four gales are reported within five degrees of the equator. Also between 5° and 10° north latitude, among 6476 observations, eight gales are reported. On Maury's chart for the eastern half of the North Pacific Ocean, among 17,854 observations, 35 gales are reported between the equator and 5° N. latitude; and between 5° and 10° N. lat. among 9352 observations, 33 gales are reported. Storms do therefore sometimes occur almost directly under the equator, but on an average only once or twice a year.

The courses of the storms mentioned in the preceding table range from 11⅓° south of west to 62° north of west. In two cases the course was south of west; in a third case the course was only one degree north of west, and in a fourth case the course was only 5° north of west. Tropical storms do therefore sometimes travel towards the equator; and it is probable that this direction occurs more frequently than the table would indicate, since many of the storms here recorded would never have been selected for investigation, if they had not advanced into the middle latitudes. The average course of the storms here mentioned while moving westward was west 24° north; and the average hourly velocity in this part of their course was 17·4 miles.

The average latitude of the storm's center when moving due north was 29½ degrees, and the latitudes range from 23⅛ to 34 degrees. During the three summer months the average latitude is 30°·6; in September it is 29°·7, and during the other months of the year 26°·7, indicating that the point where the course changes from west to east is more northerly in summer

than in winter. The average course of these storms while traveling eastward to the parallel of 40° was E. 38½° N. ranging from 17° to 60°. The average hourly velocity in this part of their course is 20·5 miles, which is almost exactly the average velocity of storms in the United States for the months of August and September according to the Signal Service observations.

Course of Hurricanes originating near the West India Islands.

Date of Storm.	Latitude of beginning.	Course while moving Westward	Velocity in miles per hour.	Latitude when moving North	Course while moving Eastward.	Velocity in miles per hour.	Rain-fall.	Investigator.	Where Recorded.
1780. Oct. 3.	16·5°				E. 61·5° N.		*Rain.*	R	Law of Sts., p. 273.
1780. Oct. 12.	11·8	W. 31° N.	17·8	23·3°	E. 39·5 N.	17·2	*Rain.*	R	Law of Sts., p. 273.
1804. Sept. 3.	15·7	W. 30 N.	20·4	31·2	E. 46 N.	18·1	RAIN.	W	J. S., v. 20, p. 17.
1821. Sept. 1.	21·7	W. 27 N.	35·0	31·2	E. 55 N.	25·0	*Rain.*	W	J. S., v. 20, p. 17.
1827. Aug. 17.	14·8	W. 29 N.	12·9	30·0	E. 43 N.	10·0	*Rain.*	W	J. S., v. 31, p. 123.
1830. Aug. 12.	17·3	W. 23·5 N.	23·8	31·4	E. 37 N.	16·3	RAIN.	W	J. S., v. 20, p. 34.
1830. Aug. 22.	22·3	W. 27 N.	18·7	30·3	E. 40 N.	16·0	Rain.	W	J. S., v. 20, p. 39.
1830. Sept. 29.	20·2	W. 33·5 N.	26·4	30·4	E. 43 N.	29·6		W	J. S., v. 20, p. 42.
1831. Jan. 13.	30·0			30·0	E. 53·5 N.	16·6	Snow.	W	U.S. N. Mag. 1836.
1831. June 23.	10·3	W. 14·5 N.	20·4					W	J. S., v. 31, p. 123.
1831. Aug. 10.	12·3	W. 25·5 N.	16·6	30·7			*Rain.*	W	J. S., v. 21, p. 192.
1835. Aug. 12.	16·3	W. 17 N.	17·8				Rain.	W	J. S., v. 31, p. 124.
1835. Sept. 3.	12·4	W. 38 N.					*Rain.*	R	Law of Sts., p. 36.
1837. July 26.	11·0	W. 29 N.		30·0			RAIN.	R	Law of Sts., p. 48.
1837. Aug. 2.	17·3	W. 31·5 N.					*Rain.*	R	Law of Sts., p. 48.
1837. Aug. 12.	17·6	W. 20 N.		31·7	E. 24·5 N.		Rain.	R	Law of Sts., p. 69.
1837. Aug. 24.	32·7				E. 47 N.	17·5	*Rain.*	R	Law of Sts., p. 109.
1837. Sept. 27.	15·7	W. 24 N.	8·3	26·2	E. 17·5 N.	13·4	*Rain.*	R	Progress, p. 13.
1839. Sept. 12.	18·5	W. 26 N.		32·2			*Rain.*	R	Progress, p. 39.
1842. Aug. 30.	21·6	W. 1 N.	10·0				Rain.	W	J. S., v. 1, p. 2.
1842. Oct. 2.	20·0				E. 18 N.	10·6	*Rain.*	W	J. S., v. 1, p. 153.
1844. Oct. 4.	18·6				E. 54 N.	30·4	*Rain.*	W	J. S., v. 2, p. 312.
1846. Sept. 11.	13·8	W. 62 N.	10·3	29·2	E. 47 N.	14·3	*Rain.*	W	J. S., v. 18, chart.
1846. Oct. 6.	14·2	W. 60 N.		30·0	E. 60·5 N.	23·5	Rain.	W	J. S., v. 18, chart.
1847. Oct. 10.	12·8	W. 11·5 S.	21·2				Rain.	R	Progress, chart.
1848. Aug. 22.	15·0	W. 28·5 N.		27·4	E. 22 N.			R	Progress, p. 337.
1848. Aug. 29.	15·0	W. 22 N.		29·0	E. 24 N.		*Rain.*	M	Phys. Geog., p. 60.
1850. Sept. 2.	16·0	W. 5 N.	13·8					W	J. S., v. 18, p. 176.
1851. Aug. 16.	13·5	W. 15 N.	17·5	27·3	E. 34 N.	18·7	Rain.	W	J. S., v. 18, chart.
1853. Aug. 30.	12·5	W. 12·5 N.	25·3	31·7	E. 24·5 N.	28·4	RAIN.	W	J. S., v. 18, p. 1.
1853. Sept. 26.	28·8			29·2	E. 27 N.		RAIN.	W	J. S., v. 18, p. 180.
1853. Sept. 29.	13·9	W. 9 N.					*Rain.*	W	J. S., v. 18, p. 178.
1866. Oct. 1.	19·0	W. 15 N.	15·0	26·4	E. 25 N.	30·0	Rain.	B	Han. Book, p. 151.
1867. Oct. 29.	18·5	W. 2 S.	15·5				RAIN.	E	Pamphlet.
1871. June 1.	23·5	W. 14 N.	12·3	31·5	E. 45 N.	23·5	Rain.	S	Rep. 1872, p. 282.
1871. Sept. 5.					E. 38 N.	15·0	Rain.	S	Rep. 1874. Map.
1873. Aug. 18.	20·0	W. 32 N.	12·3	33·0	E. 37 N.	18·4	Rain.	S	Rep. 1873, p. 1029.
1873. Aug. 20.	25·0	W. 51 N.	10·5	34·3	E. 41 N.	16·4	RAIN.	T	Met. Soc., v. 2, p. 15.
1873. Oct. 6.	21·3	W. 28 N.	9·5	24·3	E. 45 N.	30·1	*Rain.*	S	Monthly Map, '73.
1874. Feb. 7.	24·0			26·5	E. 45 N.	23·5	Rain.	S	Rep. 1874. Map.
1875. Sept. 14.	23·0	W. 22 N.	25·1	28·5	E. 24 N.	29·6	*Rain.*	S	Monthly Map.

In column 8th the word rain when italicized signifies *hard rain;* when in capitals it signifies VERY HARD RAIN, or rain descending in TORRENTS. It will be perceived that rain generally accompanies hurricanes. In four of the cases I find in the published reports no mention of rain, but it is presumed that this is simply an oversight, since in most of the other cases rain is only incidentally mentioned. In all the investigations of Redfield and Reid the circumstances upon which they insist as specially important are the direction and force of the wind; and it is only by consulting the extracts from the log-books which they have furnished us, that I have discovered any mention of accompanying rain. It is believed that tropical hurricanes *never* occur without rain. and generally the rain is described as descending in *torrents.*

Further remarks upon the preceding table are reserved for a future article. In preparing the materials for this article, I have been assisted by Mr. Edward S. Cowles, a graduate of Yale College of the class of 1873.

ART. II.—*The Colorado Plateau Province as a Field for Geological Study;* by G. K. GILBERT.

I. *Definition and Description of the Province.*

IN the Mississippi Valley and "the Plains" the strata are almost undisturbed and lie nearly level. They have, indeed, been lifted above the parent ocean, and in part raised to a height of thousands of feet, but broad areas have moved together and all flexures have been gentle. There are no traces of the foldings which characterize the Appalachian region. The prevalent features of topography are plains and hills.

From the western edge of the Plains to the Pacific Ocean the characteristic features are mountains. The strata are bent and broken, and upturned at all angles. The typical structures are structures of displacement. Within this region of great disturbance is a restricted area of comparative calm. Dislocations of strata are not unknown in it; indeed, they are of frequent occurrence; but they are less frequent, less profound, and less complex, than in the surrounding region of mountains. Its mountains are few and scattered, and its typical topographic form is the table or plateau. It is called the Colorado Plateau province.

This region of plateaus was crossed by many lines of early exploration, and the salient features of its topography were described by numerous observers. The first writer who called attention to the extent of the district, and colligated the north-

ern portions with the southern, was Professor W. P. Blake (Pac. R. R. Repts., vol. iii, part IV, pp. 8 and 42, 1856.) The title of "Colorado Plateau" first appeared in the map of Ives' Colorado River Report in 1861, and was written between San Francisco mountains and the Grand Cañon. Later usage extended the term to include the broad upland through which the Colorado has excavated its deep channel; and finally, as the minor plateaus of which the great one is composed began, in the progress of geographical knowledge, to be discriminated and named, the comprehensive title of the whole became *the Colorado Plateaus* or *the Colorado Plateau Province.* Portions of the region have been studied, described, and mapped by numerous geologists and geographers, but the chief contributions to our knowledge of the Province as a whole, and of its limits, have come from the surveys conducted by Major Powell and Lieutenant Wheeler.*

It would avail little to describe in detail the boundaries of the province without the aid of a map. On the east it is separated from the Plains by a continuous broad belt of mountains, which include the parks of Colorado and have been called the Park Mountain System. On the south and west it adjoins the Basin Range Province, a region of many short parallel ranges, separated by trough-shaped, desert valleys. Northward it is limited by mountains for which there is no comprehensive title. Its greatest extent from north to south is 700 miles; from east to west, 425 miles. It comprises, of southern Wyoming, 20,000 square miles; of eastern Utah, 50,000; of western Colorado, 30,000; of northeastern Arizona, 45,000; and of northwestern New Mexico 25,000;† making a total of 170,000 square miles, or one-twenty-fourth part of the territory of the United States. It is drained chiefly by the Colorado of the West and its tributaries, but the Sevier river heads in the western margin, and the Puerco of the East in its eastern, and the North Platte drains its northeastern angle. The plateaus which compose it range in altitude from 5,000 to 11,000 feet above the sea, but the lines of drainage are much lower, and the streams run at the bottoms of deep gorges or cañons. The plateaus are terminated in part by cliffs, and the cañon walls are cliffs. Plateaus, cañons, and cliffs are the characteristic features. The chief mountains are of volcanic origin, and they are doubly conspicuous, since

* Exploration of the Colorado River of the West and its tributaries; by J. W. Powell. Washington, 1875.

U. S. Engineer Explorations and Surveys west of the 100th meridian, vol. iii, Geology; by G. K. Gilbert, Archibald R. Marvine, Edwin E. Howell, and J. J. Stevenson. Washington, 1876.

† In defining the province in my report to Lieut. Wheeler (see U. S. Eng. Expl. and Sur. W. of the 100th mer., vol. iii, Geology, pp. 43 and 542) I have not included the portion south of the Uinta mountains. I was not aware, at the time of writing, that the plateaus south of the Uintas were continuous with those of Wyoming, the Uinta uplift not extending eastward to the Park Mountains.

they not only constitute some of the loftiest points, but are exceptional to the general character of the topography.

The climate is extremely dry—so dry that agriculture is impossible without irrigation. Vegetation is scant, except upon the heights. Below 8,000 feet altitude it is too sparse to interfere with the examinations of the geologist, and there are vast stretches of absolutely naked rock. Travel is greatly obstructed, except along certain lines, by deep cañons which ramify through the plateaus, and the selection of routes for wagon-roads and railroads is a work of great difficulty.

All this description applies more especially to the southern portions of the district. North of the Uinta mountains the streams flow in shallower and broader valleys, and are more sluggish. The Green river, the main artery of drainage, is there less deeply sunken in the plain than in its lower course, and all erosion by running water is hence less powerful. The profiles of the topography are more rounded, and accumulations of local drift and soil give rise to many grassy plains.

The only important economic mineral of the whole region is coal, and this, though unlimited in quantity, is now utilized only where the Pacific railroad affords a market. Mines of the precious metals are nearly unknown, and in default of these, which are the usual incentives to settlement in our arid territories, the region is chiefly uninhabited by whites, and portions are even unexplored, except by the ubiquitous trapper and prospector, who make no record of their discoveries. Along the western margin are Mormon settlements. The market afforded by the Pacific railroad and its dependencies, has stimulated a little farming in Wyoming, and the same result has been wrought at the south, in Arizona and New Mexico, by a line of military posts. But in the center of the province one can find a spot that is more than one hundred miles from the nearest house, excepting only the ruined and abandoned dwellings of the Pueblo Indians, who once peopled this forbidding land more densely than it is likely ever to be peopled again.

II. *How the material is exposed for study.*

As a field for the studies of the geologist, the Plateau province offers valuable *matter* in an advantageous *manner.* Let us begin with the consideration of the manner.

First, the Climate. The air is so dry that, except on the heights and at the margins of springs and streams, there is no turf, no accumulation of humus, often no soil, and so little vegetation that the view is not obstructed. From a commanding eminence one may see spread before him, like a chart, to be read almost without effort, the structure of many miles of country, and in a brief space of time may reach conclusions, which, in a

humid region, would reward only protracted and laborious observation and patient generalization. There is no need to search for exposures where everything is exposed. Dr. Newberry, speaking of one of the southern plateaus, says, "On our way to the Moqui villages we passed through a region singularly favorable for accurate geological investigation; where there is no vegetation to impede the view; where the strata are entirely undisturbed, and are cut by valleys of erosion, in the wall-like sides of which every inch of the series may be examined. In this journey we ascended in the geological scale from the summit of the Carboniferous to the base of the Cretaceous series. Of this interval there is no portion of which the exposures are not as complete as could be desired." (Geol. Ives' Exped., p. 77.)

This aridity is not peculiar to the plateaus: it pertains to the Basin Ranges, and in a less degree to the plains. But in the ranges the most arid portions are the valleys between the mountain ridges, and these are filled with monotonous Quaternary gravels and clays, which hide all other beds, while the ranges themselves, which are of more interest to the geologist, catch all the precipitation, and are in some degree clothed with verdure.

Second, the Drainage. The Plains and the Plateaus are alike drained by great rivers, which rise in lofty mountain regions, and traverse them on their way to the sea; but there the resemblance ceases. The rivers which cross the Plains flow over them in broad shallow valleys. The soft rocks of the intervening benches decay more rapidly than they are undermined, and their rounded outlines are clothed with soil. But the Colorado and its branches flow across the Plateaus in deeply carved, narrow cañons. Where the Green river, which is the main fork of the Colorado, enters the Uinta mountains, it is 2,000 feet below the adjoining plateau, and where the Colorado leaves the plateaus, it emerges from a gorge 4,000 feet deep. In the interval the current courses, almost without exception, between high cañon walls. Into this deep channel are gathered the waters of the uplands. Empowered by the rapidity of its descent, each tributary river has carved a cañon of its own, and so too has each branch and creek tributary to a river, until the whole tract is divided by a labyrinth of ramifying cañons. When the rain falls—for it does sometimes fall here—it flows down rapidly into the gorges, and washes with it the loosened particles of disintegrating rock. Then in time of flood the deepening waters, constrained to a narrow channel, rush forward with impetuous velocity and sweep out the detritus. The rocks of the upland are removed as fast as they decay, and soil cannot accumulate. Thus does thorough drainage conspire with aridity to prepare for the geologist a land of naked rock.

No less important to the student are the cañons themselves. They bear the same relation to a plain that geological cross-sections do to a geological map. They introduce in all categories of observation a third dimension, and enable the contemplation of all the phenomena of structure with reference to depth as well as length and breadth.

Third, Glacial drift and Lava-sheets. While these are, in themselves, fertile subjects of study, they are also obstructions to observation, in so far as they conceal other formations from view; and it is as obstructions that I here refer to them.

Moraines are unknown in the southern half of the Plateau province, and in the northern they are not found at a lower altitude than 7,500 feet. The few that exist pertain to what were local glaciers. There was no general ice-mantle. The southern limit of glacial phenomena is in north latitude 38° 30′, or about on the parallel of St. Louis. In the epoch of ice the climate of the Plateaus doubtless bore the same relation to that of the eastern seaboard that it does now. It was then, as now, a little colder than the latter, and a great deal drier; and it was its dryness which prevented, even at an altitude of some thousands of feet, the accumulation of such a deluge of ice as visited the Atlantic seaboard in the same latitude. Only on the highest mountains was the winter's precipitation in excess of the summer's melting.

But while the mantling by glacial drift is inconsiderable, that by extravasated material is of great extent. Some of the largest continuous lava fields of our country belong to the Plateau region. A field in southern Utah stretches ninety miles from north to south and seventy miles from east to west; and the corresponding dimensions of one in New Mexico and Arizona are one hundred and seventy-five, and one hundred and forty miles. Almost coalescent with the latter is a third field which includes the San Francisco group of peaks in Arizona. Beneath these, and beneath minor floods of lava, are buried a tenth part of the sedimentary rocks of the Plateaus.

In brief, the strata of the Plateau region are exposed with exceptional thoroughness. They are indebted to a dry climate, in ancient and modern times, for the almost entire absence of glacial drift, and for the suppression of vegetation. They are indebted to peculiar conditions of drainage for their poverty of soil, talus, and local drift, and for a system of natural cross-sections. Their chief detraction is a mere restriction of their area of exposure by overlapping lavas.

III. *The material for study.*

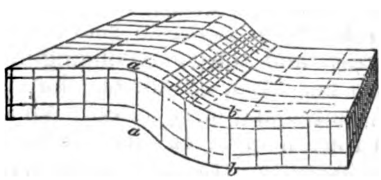
It remains to consider the nature of the material which is so fully exhibited, and examine its claims to attention. It pertains chiefly to four departments of geological investigation, viz:

Mountain building by displacement; Mountain building by eruption; Stratigraphy; and Erosion; and will be discussed under these heads, in the order indicated.*

Mountain building by displacement. The Plateau Province differs from the mountain provinces by which it is surrounded in the degree and not in the kind of disturbance to which its sediments have been subject. Faults and folds abound through its whole extent, but they are comparatively of great simplicity. They are indeed so simple that they can be completely known. Their entire phenomena may be comprehended, measured, described, and delineated. The course of many a fault can be traced from end to end, and its throw measured at every step. The form of many a fold can be determined thoughout, and pictured or modelled in miniature, with every detail of flexure.

Now, faults and folds are the *elements* of the displacements which give rise to mountains, and to study them is to study the very rudiments of mountain structure, and to acquire a knowledge of mountain structure is to lay the indispensable geological foundation for a true theory of the origin of mountains. Hence the value of this opportunity to study the elements of displacement in an uncombined condition, and in their simplest compound forms. To enforce this proposition, which is of more importance than might at first appear, I will take an illustration from the material already gathered, and, to do so, it will be necessary to explain one or two terms that have had to be coined to describe the new group of facts.

1.

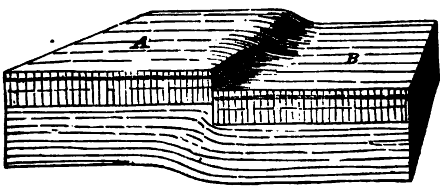


In an anticlinal fold the strata dip in two directions away from the axis. In a synclinal fold the strata dip from two directions toward the axis. There is in nature a third type, which involves a dip in only one direction. This is the *monoclinal* fold. It is a double flexure, connecting strata at one level with the same strata at another level. In figure 1, the curvature between *aa* and *bb* is a monoclinal fold.

* The writer travelled, during three summers, with field parties of the Survey in charge of Lieut. George M. Wheeler of the U. S. Engineers, and during a fourth with a field party of the Survey in charge of Major J. W. Powell. His reports to Lieut. Wheeler are published in the third volume of the reports of "Explorations and Surveys west of the 100th meridian." Besides his own observations, the chief sources from which he has derived the material here presented, are: 1. The observations of Major J. W. Powell, published in his report on the "Exploration of the Colorado River of the West and its tributaries;" and, in part unpublished. 2 and 3. The observations of Mr. E. E. Howell and of the late Mr. A. R. Marvine, published in vol. iii, of Lieut. Wheeler's Reports, and in part unpublished. 4. The observations of Dr. J. S. Newberry, published in Ives' "Explorations of the Colorado," and in part unpublished. 5. The writings of Mr. Clarence King, "Fortieth Parallel Survey," vol. iii. 6. Mr. T. B. Comstock's report in the U. S. Engineers' "Reconnaissance of northwestern Wyoming." 7. Prof. E. D. Cope's report to Lieut. Wheeler, published in the U. S. Engineer report for 1875.

It is evident that if two monoclinal folds are combined back to back, the result will be an anticlinal; if they are joined foot to foot, they will form a synclinal. Hence the monoclinal fold is a simpler element of displacement than either of the others.

When a portion of the earth's crust—it may be one that is measured by miles, or one that is measured only by feet—is moved bodily either up or down, while the portion adjacent to it is not so moved, the line along which they adjoin, will be marked by a fault, by a monoclinal fold, or by some combination of the two. The fault and the monoclinal fold are alternative manifestations of simple displacement, and are, in a certain sense, equivalent. There are several different ways in which they are combined with each other. If one travels along the line of displacement that separates two blocks of strata which stand at different levels; he may find that at one point the beds are continuous, and curve downward from the upper level to the lower; and that at another point they are broken across, and the dissevered edges have slidden past each other.



2.

Or, if one could descend into the earth along the plane of dislocation, he might find that one stratum had been fractured, while another, less rigid, or coerced perhaps by a greater pressure of superincumbent rock, had been only flexed. A third mode of combination is exhibited when a bed yields at first by flexure, and is finally fractured before the completion of the dislocation. These phenomena are illustrated by figure 2, which is an ideal representation of two blocks of strata, *A* and *B*, cut out from their surroundings, so as to exhibit the manner of their relative displacement. The front of the segment shows a flexed bed underlying a faulted one. The top of the segment shows a fault at the front, a monoclinal fold at the back, and a compound displacement midway.

The monoclinal fold is not unknown in other parts of the world, but it has attracted little attention, and I am not aware that it has been described as abundant in any region. But in the region of the Plateaus it is not merely a feature of occasional occurence; it is a characteristic type of displacement, and is rivalled in frequency only by the fault.

Let us now turn from the displacements, to the disturbed masses of rock which they divide. A fault or a monoclinal fold is merely the record, at the margin of a solid block, of a movement that has affected the entire block, and it bears the same subsidiary relation to the movement of the block, that a

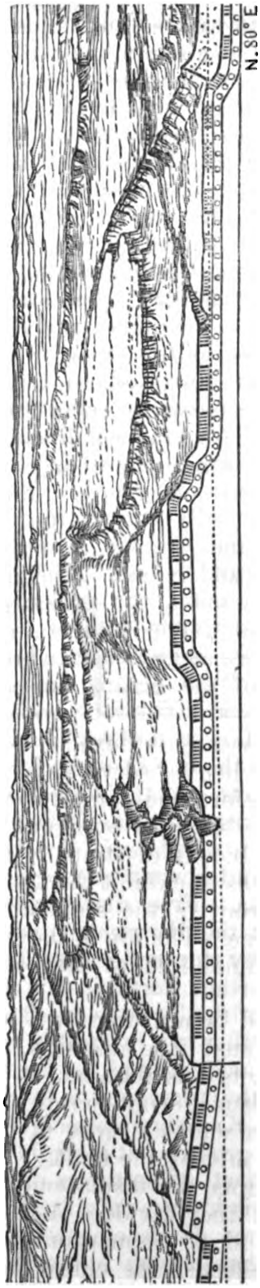


Fig. 3. Section from west to east across the plateaus north of the Grand Cañon of the Colorado, with bird's-eye view above. Horizontal scale, 16 miles to the inch; vertical scale, 4 miles to the inch. The base line marks the level of the ocean; the dotted line above it, the level of the river.

line bears to the angle or area which it limits and defines. A large portion of the Plateau region is divided into great blocks —usually a few miles in width and many miles in length—and these have been unequally lifted above the ocean which deposited their common sediments, so that each differs from its neighbor in altitude. They are bounded by lines of displacement. The blocks which have been lifted highest have been most exposed to erosive agencies, the tendency of which is to pare away eminences and reduce all to a common level; but as a rule, the highest plateaus mark the positions of blocks that have risen above their neighbors. The forms of many blocks are perfectly portrayed in the topography, and all can readily be traced out and defined by the study of the displacements.

In illustration I have borrowed, through the kindness of Major Powell, a wood-cut from his report of the "Exploration of the Colorado," and if the reader will examine it attentively, he will obtain a clearer idea of the structure I have described, than I can hope to convey in words. The sketch is not an ideal one, but was carefully drawn to represent a tract of country, lying in Utah and Arizona, of which the main geological features are clearly understood. The geological section in the foreground is, in the main, the section which is exposed in the walls of the Grand Cañon, and is 106 miles long. The vertical scale is four times as great as the horizontal. The base line marks the level of the ocean, and the dotted line the level of the Colorado river. The rock bed marked with small circles stands for the Lower Aubrey Group, a member of the Carboniferous System; the one above it for the Upper Aubrey Group, also Carboniferous, and the dotted stratum, seen at the right, is the so-called Trias. In the bird's-eye view beyond the section, the foreground is of plateaus floored by the limestone of the Upper Aubrey, and beyond rise terraces built of Triassic and more recent strata. Five displacements are exhibited. Beginning at the left: the Hurricane displacement is a fault where it is intersected by the section, and has a throw of 2,500 feet. Seventy miles farther north it is a combination of fault and fold. The throw of the To-ro′-weap fault is only 800 feet, and it disappears altogether in a few miles. The West Kai′-bab displacement is a monoclinal fold as far as it appears in the sketch, but farther south it changes to a fault. Its throw is 2,000 feet. The East Kaibab displacement is a double monoclinal fold in the foreground but a single one in the distance. Its total throw is 3000 feet. The throw of the Paria displacement is 1800 feet. It is known only as a simple fold. Along the lines of the first three displacements the eastern wall has risen, or the western has fallen; but with the remaining two the reverse is the case.

[To be continued.]

ART. III.—*Notices of Recent American Earthquakes*—No. 6; by Prof. C. G. ROCKWOOD, Jr., Rutgers College.

IN the following notices, facts given by *single* newspaper reports, and which could not be otherwise verified are printed in smaller type, and the source from which they were obtained is indicated.

For information received I am indebted to John M. Batchelder, of Boston, and Samuel Barnet, of Washington, Ga.

1874.

May.—The disturbances at Bald Mountain, N. C., in February and March, already noticed (III, ix, p. 332) were reported as continuing at intervals during the months of April and May. (U. S. Signal Service.)

July 23.—A light shock at Camp Russell, Neb. (U. S. Sign. Serv.)

Aug. 3.—During the evening a light shock from the east at Clifton, San Bernardino Co., Cal. (U. S. Sign. Serv.)

Dec. 12.—A slight shock between 10 and 11 P. M at Garrison's, N. Y.

1875.

January.—Earthquakes preceded and accompanied an eruption of the volcano Trölladyngja, in the central part of Iceland. The volcanic disturbance appears to have begun by subterranean thunders during December, 1874, extending through nearly two-thirds of the island. Early in January, 1875, earthquakes occurred in all directions and then an old extinct volcano near Vatrayskud opened and for four weeks continued to emit ashes, lava, etc. When this eruption ceased, another extinct volcano near Myvatu, 100 miles farther north, opened and continued in action for several weeks. Both of these eruptions occasioned great destruction of life and property. Early in March there seemed to be a general upheaval of the earth in the whole central portion of the island. The ashes from these or still later eruptions fell to the depth of several inches on the coast of Norway in the latter part of April. It is stated that "the geysers have dried up since the eruption began, and instead of water emitted quantities of hot smoke and ashes."

Jan. 24.—A heavy shock at 4 A. M. in Butte, Plumas, and Sierra counties, Cal.; felt also at Sacramento, Cal., and Carson City, Nev., where two shocks were reported, the first light, the second quite severe and lasting several seconds. The direction was from the northeast.

Feb. 7.—Two severe shocks at San Francisco, Cal., the first at 10.56 and the second at 11.50 A. M., each lasting two to four seconds. (U. S. Sign. Serv.)

Feb. 16.—A shock at Orezava and Minatitlan on the Isthmus of Tehuantepec. (J. M. B.)

Feb. 11 and 18.—A letter from Guadalajara, Mex., dated March 2, 1875, says: "Since the 11th ult. we have had almost continually slight shocks of earthquake. In all we have had but four very severe shocks; the first (two?) on the night of the 11th and two on the 18th. The majority of the churches in Guadalajara are greatly damaged. In San Cristobal, a small village about eight leagues from this city, 35 or 40 lives have been lost and nearly all the houses reduced to ruins."

March 9 and 10.—The same writer says under date of March 10: "The earthquakes continue. We had one yesterday that lasted three minutes, not severe. We felt a sharper one to-day at 1.20 P. M. but it only lasted a few seconds."

March 9.—A shock at Phœnix, R. I. (J. M. B.)

April 1.—A heavy shock in the evening at Eureka, Nev. (J. M. B.)

May 6.—A shock at Wolfborough, N. H. (J. M. B.)

May 15.—A slight shock about 10.15 A. M. at Cambridge, West Roxbury and Milton, Mass.

May 18.—A very destructive earthquake occurred at 10.10 A. M. in the Colombian Andes. The area affected extends from Carthagena and Maracaybo on the north to Bogota and Honada on the south, over six degrees of latitude. The center of disturbance was at the city of San José de Cucuta. This is a city of Venezuela, situated on the border of New Grenada, in N. lat. 7° 30′, W. long. 72° 10′, and before the catastrophe had a population of 18,000. It is between the two ranges of the Andes which unite not very far south of the city. The first premonition of the disturbance at Cucuta was a subterranean rumbling noise heard on the night of the 17th, but unattended by any tremors. At 11.10, (some accounts 11.30) on the forenoon of the 18th two tremendous shocks of earthquake occurred followed after a short interval by three others of nearly equal intensity. By these shocks, the city and most of the surrounding villages within a radius of twenty miles were completely destroyed, with great loss of life and property. In Cucuta only one building remained standing; and in San Cristobal (population 11,000) only one house was left and that so shattered as to be unsafe.

The destruction involved nine villages in Venezuela, chiefly in the department of Merida, and ten in New Grenada in the departments of Santandar and Pamplona. The loss of life is estimated at 5000, and of property at $7,000,000. Immediately after the first shocks, the Lobotera volcano, near the city, began to emit masses of molton lava, which falling in the city set fire to the ruins, and thereby added to the destruction, the

horrors of which were still further enhanced by the pillage and robbery which took place. Lighter shakings were felt in various parts of this region for a number of days after the first shock. Thus advices from Maracaybo, May 29, say: "Light shakes here every day since." In Cucuta, Trujillo, Merida, and Mendoza, "tremors perceptible at intervals for forty-eight hours." A telegram from Bucaramanga, May 24, says: "The earthquake continued last night. The cathedral in Pamplona fell." A telegram from Chiquinquira, May 22, says: "the shocks are repeating. Two last night, one to-day." It was noticed as a remarkable fact that the disturbance was only felt on the west side of the mountain range.

May 18.—A prolonged shock just before midnight at St. Thomas, W. I. (J. M. B.)

May 30.—Advices of this date from City of Mexico say: "slight shocks have been felt in Jalisco." (N. Y. Times.)

June 4.—A shock at 3 A. M. felt on board the ship Hamilton in N. lat. 19° 16′, W. long. 57° 51′. "When the disturbance first began the sea was quite smooth, but as the shock increased in violence the waters became correspondingly agitated. Suddenly the vessel received a shock as if she had grounded, and a peculiar rumbling noise filled the air. Simultaneously with the shaking the sky assumed a dull leaden hue. The atmosphere was also thick and hazy. There was little if any wind at the time, yet the vessel was tossed about as though in the midst of a gale. The duration was long enough to enable those who were below to reach the deck, estimated as fully ten minutes."

June 13.—Several shocks at Chinaltenango, San Salvador.

June 16.—A shock at San Francisco, Cal. (J. M. B.)

June 18.—A shock in the forenoon in western Ohio and Indiana. It was most severe in the vicinity of Urbana and Sidney, Ohio, where walls were cracked, chimneys thrown down, etc.; but it was sensibly felt at Columbus, O., and Indianapolis, Vincennes and Jeffersonville, Ind., and slightly at Cincinnati and Chicago. It was not felt at Terre Haute, nor in the vicinity of Lafayette and Logansport, Ind. The statements in regard to time are various and contradictory. The United States Signal Service Observer at Indianapolis reports the shock as occurring at 7.43 A. M. All other accounts vary from 9 to 11 A. M. *No account mentions more than one shock.*

Slight shocks were felt in San Francisco on the same forenoon.

July 3.—Three shocks at 12.05 P. M. at Nuevitas, Cuba. The first and last slight, the second rather severe, the whole lasting about fourteen seconds. (N. Y. Times.)

July 28.—A shock at 4.10 A. M. felt quite generally through-

out the northwestern part of Connecticut. It extended from Hartford and Springfield on the east to the line of the Housatonic R. R. on the west, and from Danbury and Waterbury on the south, to Chester and Becket, Mass., on the north, being felt at numerous places in Litchfield and Hartford counties. At most places the shock was preceded or accompanied by a rumbling noise. At Collinsville it lasted fifteen seconds. At Winsted it is stated to have lasted forty seconds, the sound coming from the north and passing away toward the south.

July 28.—A shock at 6.05 P. M., at Milledgeville, Ga., with a loud explosion. (Atlanta Herald.)

July 31.—Advices of this date from the City of Mexico, report an earthquake in Jalisco. (N. Y. Times).

Aug. 3.—A shock at 3 A. M. in St. Thomas, W. I.

Aug. 8.—A heavy shock in the morning at Hollister, Cal. (J. M. B.)

Aug. 29.—A shock was felt at 8.30 P. M., on board the bark St. Lawrence, in N. lat. 18° 50′, W. long. 61° 30′, being between St. Thomas and the Island of St. Bartholomew, 140 miles from land. It lasted thirty seconds. (N. Y. Herald.)

Sept. 17.—Three shocks at St. Vincents, W. I. The last about 9 P. M. was rather severe. (London Times Correspondence.)

Sept. 25.—A shock about 9 P. M. at Stepney, Conn. (New Haven Palladium.)

Oct. 7.—Slight shocks at Memphis, Tenn., and Cairo, Ill. (U. S. Sign. Serv.)

Oct. 14.—A sharp shock about 6 P. M. at San Francisco, and in the Santa Clara Valley, Cal. The vibrations were from east to west. Reports from various points on the coast from Santa Cruz to Cape Mendocino, mention a heavy sea without wind, and the waves rolling up on the beach 100 to 300 feet beyond the usual high water mark, for several days after the above. From this it might be inferred that this earthquake had its origin somewhere in the Pacific Ocean.

Oct. 15.—A shock at 1 A. M. at Kingston, Jamaica, W. I. (J. M. B.)

Oct. 27.—Three shocks in the night at Memphis, Tenn.; strong enough to rattle windows. Also a shock, probably the same, at 9 P. M. at Purdy, McNairy Co., Tenn.

Oct. 31.—A slight shock at 9.18 P. M. at Cambridge, Mass., of three or four seconds duration. Barometer 29·70 in.

Nov. 1.—A somewhat severe earthquake was felt at 9.55 P. M., in the northern part of Georgia. It was felt at Gainesville, Atlanta, Madison, Athens, Union Point, Washington, Augusta, Forsyth and Macon, Ga., and at Spartanburg and Columbia, S. C. It lasted about thirty seconds, and at Wash-

ington and Augusta some observers noticed two or three shocks. A rumbling was heard at the former place. The reports of the direction of vibration are too contradictory to be briefly stated. No damage was done, but the shock was sufficiently strong "to cause a mirror to nod back and forth from the wall."

Nov. 2.—Advices of this date from San Francisco say: "A severe shock of earthquake is reported at Fort Yuma on the Colorado River."

Nov. 7.—A heavy shock in San Benito County, Cal., accompanied by a harsh rumbling noise. The direction of vibration was from east to west.

Nov. 8.—A shock at 4.40 A. M., felt at Leavenworth, Lawrence, Burlingame (direction S.W. to N.E.), and Manhattan, Kansas. At the latter place the time was "about 5 A. M.," the direction west to east and lasting a minute.

Nov. 12.—A shock at 2 A. M. at Knoxville, Tenn., lasting ten seconds. The vibration was from west to east, and accompanied by a rumbling noise.

Nov. 14.—A shock at San Francisco and San Jose, Cal. (U. S. Sign. Serv.)

Nov. 15.—A smart shock at 7.55 P. M. at San Francisco, Cal.; vibrations east and west.

Nov. 27.—A shock at San Francisco, Cal. (U. S. Sign. Serv.)

Dec. 1.—Two slight shocks at 4 and 6 A. M. at Keene, N. H.

Dec. 3.—A heavy shock in the afternoon at Grass Valley, Cal., lasting ten seconds, vibrations north and south. Felt slightly at 3 P. M. at Carson City, Nev.

Dec. 4.—The town of Abancay, Peru, was destroyed by an earthquake, "between 4 P. M. of the 4th and 9 A. M. of the 5th, no less than thirty-seven shocks occurred, some of them very severe" This town is east of the Andes and some fifty miles from Cuzco.

Dec. 8.—On the night of the 8th and 9th, an earthquake occurred in Porto Rico by which the town of Arecibo was almost entirely destroyed, "two churches and only six houses remaining."

Dec. 8.—On the same day as the preceding, hour not stated but apparently about breakfast time, the bark Mora experienced an earthquake at sea in N. lat. 10° 7′, W. long. 42°.

Dec. 9.—A slight shock at 3 A. M. at Nebraska City, Neb.

Dec. 15.—A shock at 2.45 P. M. at Maricopa Wells, Arizona Terr. (U. S. Sign. Serv.)

Dec. 21.—A shock at Santa Barbara, Cal. (U. S. Sign. Serv.)

Dec. 22.—An earthquake was felt about 11.45 P. M. in Virginia. It was most severe at Richmond and vicinity, where three distinct shocks were noticed, lasting twenty or thirty

seconds, and accompanied by a rumbling noise. The shocks "were not sharp or sudden, but coming on rather slowly, swelling in force, and then quickly dying out." The direction of the vibration was north and south, and it was sufficiently strong to knock down plastering, etc. It was felt toward the north as far as Washington and Baltimore, and toward the northwest at Staunton and Gordonsville, at which latter place the time is stated at 11.30, and the duration "fully three seconds." The U. S. Signal Service reports: "Two shocks at 11.30 at Fortress Monroe, Va.; about 11.30 at New Market, Ind.; shock lasting twenty seconds at 11.45 at Greensboro, N. C.; two shocks from east-southeast to north-northwest, the first lasting five or six seconds, the second not quite so heavy at 11.40 (Washington time) at Alto Vista, Va.; two shocks from east to west, first lasting ten or fifteen seconds, the second milder, at 11.33 at Petersburg, Va.; shock from northeast to southwest with rushing roaring noise at Weldon, N. C."

Dec. 23.—A shock at night in Placer, Nevada and Yuba Counties, Cal.

Dec. 24.—A shock in the evening at Grass Valley, Cal. (N. Y. Times.)

1876.

Jan. 7.—Three shocks at the Island of St. Thomas, W. I., in the morning, "the first at about four o'clock, the second at about half past four, which was very severe, and the last three minutes later." (Newark Daily Advertiser.)

Jan. 7.—A shock at 2.20 P. M. at Warner and Contoocookville, N. H. Its apparent course was from west to east and its duration two minutes.

Jan. 8.—A shock at 4.30 P. M. at Lockport, N. Y. (U. S. Sign. Serv.)

Jan. 15.—A severe shock at midnight at China, Me.

Jan. 21.—A shock between 3 and 4 A. M. at San José, Santa Cruz and San Francisco, Cal. (U. S. Sign. Serv.)

Jan. 27.—Two shocks at Adrian, Mich. (U. S. Sign. Serv.)

Jan. 29.—A shock at 9.05 P. M. at Annapolis, Md. (U. S. Sign. Serv.)

Feb. 7.—A shock in the City of Mexico. (U. S. Sign. Serv.)

Feb. 27.—A shock at Detroit, Mich.

March 25.—Two slight shocks at 6 A. M. and 1 P. M. at Oakland, Cal. (U. S. Sign. Serv.)

April 10.—A shock was felt in a large portion of St. Mary's County, Md., attended by a rumbling sound. (N. Y. Times.)

New Brunswick, N. J., May 3, 1876.

ART. IV.—*On Roscoelite, a Vanadium Mica;* by JAMES BLAKE, M.D., San Francisco, California.

THE mineral, to which I have given the name of Roscoelite, —in honor of Professor Roscoe, of Manchester, who has done so much for the chemical history of vanadium,—is a well marked species of mica, containing quite a large percentage of vanadium. It was found in a gold mine at Granite Creek, El Dorado County, in the lower hills on the western slope of the Sierra Nevada. It occurs in the hanging wall of a small quartz vein, the country rock being porphyry. The mica appears to have been principally deposited in fissures in the porphyry, and is usually found in layers from a tenth to half an inch thick, and seldom extending continuously for more than two or three inches. It is also found filling cavities in the quartz. The crystals are quite brilliant, of a dark-green color, seldom more than 0·1 inch long, and, when occurring in fissures, form two series starting from each side of the fissure and meeting in the center. They are also found in nodules with a stellar arrangement, more particularly in the cavities of the quartz. They are strongly doubly refracting. Sp. gr. 2·33. They weather into a light yellow wacke. The whole thickness of the vein-matter in which the mica is found is not more than a few inches. The mine in which it occurs has been worked for gold, and it is in these micaceous deposits that the greater part of the gold is found. Some portions are extremely rich, as much as $240 having been washed out from a single panfull; and while at the mine I saw $40 taken from a few handsfull. The gold is commonly found in the form of fine scales which have been deposited between the crystals of the mica. So generally is it diffused that it is impossible to find a piece of the mica as large as a bean that does not contain gold. The mine is worked by means of an open cut, now about 30 feet deep and 150 feet long.

The most interesting fact connected with this mineral is the large proportion of vanadium it contains, and that too, in a form in which it has not before been found, unless the small traces of it detected in some basalts should be part of an analogous compound. When I first discovered the mineral, I expected to find a mica rich in chromium, and, on heating some of it in a test tube with HCl, I obtained a green solution. Finding that by continued boiling with acid the whole of the color was entirely removed from the mica, I availed myself of this method to determine the quantity of what I considered to be chromium; fusing the residue from the acid solution with carbonate of soda and niter, and precipitating with lead, I also ascertained the amount of the alkalies; and, in presenting some specimens

of the substance to the Microscopical Society and at the Academy of Sciences of California in September, I made the general statement that it was a potash-mica, containing 23 per cent chromic oxide and traces of lithia. It was not until I had sent a specimen of the mineral to Dr. Genth to analyze that the presence in it of vanadium was discovered, and to him is due the entire credit of having first detected the true character of this interesting mineral. I have availed myself of the action of nitrohydrochloric acid on the mineral to prepare a considerable quantity of vanadic compounds for physiological experiment, as this affords about the easiest method of obtaining vanadic acid, although it is impossible thus to extract all the vanadium from the mica.

Art. V.—*On some American Vanadium Minerals;* by F. A. Genth.

1. *Roscoelite.*

I am indebted to Dr. James Blake of San Francisco, California, for a small quantity of the very interesting mineral, which he called "Roscoelite," in honor of Professor Roscoe, whose important investigations have put vanadium in its proper place among the elements.

Roscoelite occurs in small seams, varying in thickness from $\frac{1}{32}$ to $\frac{1}{16}$ of an inch in a decomposed yellowish, brownish or greenish rock. These seams are made up of small micaceous scales, sometimes $\frac{1}{4}$ of an inch in length, mostly smaller and frequently arranged in stellate or fan-shaped groups. They show an eminent basal cleavage. Soft. The specific gravity of the purest scales (showing less than one per cent of impurities) was found to be 2·938; another specimen of less purity gave 2·921. Luster pearly, inclining to submetallic. Color dark clove-brown to greenish-brown, sometimes dark brownish-green.

Before the blowpipe it fuses easily to a black glass, coloring the flame slightly pink. With salt of phosphorus gives a skeleton of silicic acid, a dark yellow bead in the oxidizing flame, and an emerald-green bead in the reducing flame. Only slightly acted upon by acids, even by boiling concentrated sulphuric acid; but readily decomposed by dilute sulphuric acid, when heated in a sealed tube at a temperature of about 180° C., leaving the silicic acid in the form of white pearly scales, and yielding a deep bluish-green solution. With sodic carbonate it fuses to a white mass. The roscoelite, which I received for investigation was so much mixed with other sub-

stances, such as gold, quartz, a feldspathic mineral, a dark mineral and very minute quantities of one of orange color, that it was impossible to select for analysis material of perfect purity. For this reason I have delayed the publication of my results, which were obtained over one year ago, in the hope of being able to repeat my analyses with better and purer specimens; but I now give the results of my analyses because there is no prospect of getting any more of this mineral, as will be seen from a letter of Dr. Blake, dated San Francisco, April 5th, 1876, in which he says, that the mine in which it occurs cannot be worked any farther until a tunnel has been run, and that it is quite uncertain when this will be done.

Although by no means perfect, my results approach the truth and give a fair idea of the composition of the mineral, even if the evident admixture of other minerals, varying in the different samples analyzed, from about one to perhaps over twelve per cent, does not permit one to calculate the atomic ratio of the constituents and establish the constitution of this species. There is especially an uncertainty with reference to the quantities of silicic acid, alumina and potassa which belong to the roscoelite, or which may have been introduced by admixtures of feldspathic and other minerals, as will appear from the results given below, which show that the mineral, when decomposed with sulphuric or dilute hydrofluoric acid generally gives only about six per cent of potassa, while fusion with calcic carbonate and ammonic chloride yields from eight to nine per cent. Some of these uncertainties could have been removed, if a larger quantity of the mineral had been at my disposal.

Particular attention was paid to the correct determination of the vanadium and the form in which it exists in the roscoelite.

The separation of vanadium is attended with great difficulties, and I have not found any of the methods of separation to give fully reliable results. This is in part owing to the incomplete precipitation of the vanadic acid, and in part to the impossibility of washing the precipitates completely without loss of vanadium. It was therefore always determined by the only method which I found to give fully reliable results—by titration with potassic permanganate.

After the separation from the other elements, the vanadic acid was reduced by hydrosulphuric acid into V_2O_4, which, after the excess of hydrosulphuric acid had been expelled by continued boiling, was re-oxydized into V_2O_5 by the permanganate. I have satisfied myself by numerous experiments that, no matter whether only a very minute quantity of sulphuric acid is present, or a very large excess, the V_2O_4 is completely oxidized into V_2O_5 by this process.

For the determination of the state of oxydation of the vana-

dium in the roscoelite, a quantity of the mineral was dissolved in dilute sulphuric acid in a sealed tube at a temperature of about 180° C., and was titered after cooling; the liquid was then reduced by hydrosulphuric acid, and after boiling off the excess of the latter, it was again titered. From the quantity of oxygen required for oxidation in both cases it was found that vanadium in the mineral is present as $V_6O_{11} = 2\,V_2O_3, V_2O_5$.

The determinations of the other elements were made by the usual methods.

The finely-powdered mineral was dried (unless otherwise stated) for two days over sulphuric acid, and the different samples gave the following results:

(*a.*) *Purest scales.*—The analysis was made by dissolving one portion in sulphuric acid and determining in this the quantity and state of oxidation of the vanadium, the silicic acid and insoluble impurities. The latter were left behind in dissolving the silicic acid in sodic carbonate and gave 0·85 per cent; a second portion was decomposed by sodic carbonate and nitrate, and a third for the determination of the alkalies by J. L. Smith's method. The V_6O_{11} given below is the mean of the two determinations. (*b.*) Another sample, not quite as pure as *a*, was analyzed by fusion. (*c.*) Still more contaminated with impurities, was analyzed by dissolving in dilute sulphuric acid in a sealed tube, &c., *cα* is the result of this analysis, *cβ* after deducting 11·45 per cent of impurities. (*d.*) Another sample was decomposed by dilute hydrofluoric acid; the analysis was unfortunately lost excepting the determinations given below; the material for this analysis had not been dried over sulphuric acid. (*e.*) This sample was dried over sulphuric acid for several weeks; a portion, which was decomposed by sulphuric acid, gave 5·37 per cent insoluble silicates, 0·23 per cent of gold and 43·24 per cent of silicic acid; the V_6O_{11} was determined by difference. The results given below were obtained by decomposing the mineral by fusion.

		a	*b*	*cα*	*cβ*	*d*	*e*
Insoluble silicates, quartz, gold, &c.	=	[0·85]	....	11·45	....	8·91	[5·60]
SiO_2	=	47·69	47·82	43·46	48·60	....	46·81
Al_2O_3	=	14·10	12·60	10·52	11·76	....	15·78
FeO	=	1·67	3·30	2·03	2·27	....	1·58
MgO	=	2·00	2·43	1·74	1·95	....	2·31
CaO	=	trace	trace	0·20	0·23	....	trace
Na_2O (trace Li_2O)	=	0·19	0·33	0.30	0·34	5·96	0·60
K_2O	=	7·59	8·03	5·35	5·98		8·89
V_6O_{11}	=	22·02	21·36	20·50	22·92	....	20·16
Ignition	=	4·96	5·13	5·32	5·95	6·34	3·87
		100·22	101·00	100·87	100·00		100·00

A mineral, very similar in composition and perhaps a compact impure variety of roscoelite is found associated with the scales. It has the appearance of a massive dark green chlorite or that of some varieties of serpentine. The analysis was made by fusion, &c., and gave:

SiO_2	= 46·09	Na_2O	= 0·18
Al_2O_3	= 17·46	K_2O	= 8·66
FeO	= 1·95	V_6O_{11}	= 17·53
MgO	= 2·18	Ignition	= 6·37
			100·42

2. *Psittacinite, a new hydrous vanadate of lead and copper.*

In a paper on American Tellurium and Bismuth minerals, read before the American Philosophical Society at the meeting of August 21st, 1874 (Proc. Am. Phil. Soc., xiv, 223–231), I mention, on the authority of Mr. P. Knabe, a siskin-green pulverulent mineral from the "Iron Rod Mine," Silver Star District, Montana, as a *new* "Tellurate of lead and copper." I had at that time no opportunity to examine into the merits of this mineral, having mislaid the small sample which he had sent me. On receiving a copy of my paper, Mr. Knabe furnished me with several specimens, which gave me a sufficient quantity of fair material for an analysis. A qualitative examination proved it to be a hydrous *vanadate* of lead and copper and *not a tellurate.*

When I communicated this result to Mr. Knabe he gave me an interesting account of how he fell into his error. At the Uncle Sam's Lode, in Highland District, occurs with the tetradymite a siskin-green mineral, which has not yet been analyzed, but which appears to be a tellurate. It looks exactly like the pulverulent variety of the psittacinite from the Iron Rod Mine. When Mr. K. dissolved the latter in hydrochloric acid, the evolution of chlorine indicated the presence of a higher oxide; the solution precipitated with an excess of ammonic sulphide gave sulphides of lead and copper and a filtrate which, on addition of an acid, gave a black precipitate—vanadic sulphide—which he mistook for tellurous sulphide.

Psittacinite occurs in very thin cryptocrystalline coatings, sometimes showing a small mammillary or botryoidal structure, also pulverulent; color siskin-green, sometimes with a grayish tint, to olive-green. Before the blowpipe it fuses easily to a black shining mass. With fluxes gives the reactions of vanadium, lead and copper. Soluble in dilute nitric acid, the solution yielding on evaporation a deep red mass.

As it was impossible to get any of the mineral in a pure state, I had to use coatings with quartz attached to them, sometimes contaminated with a little limonite; but these admixtures

could not influence the analysis farther than very slightly with reference to the amount of water which it contains.

The following are my results:

		a	b	c	d	e
PbO	=	41·36	50·17	42·89	27·12	42·38
CuO	=	14·34	16·66	14·72	9·75	15·03
V_2O_5	=	14·64	19·05	15·87	9·96	15·77
H_2O	=	7·42		not determined	....	7·25
SiO_2	=	15·13	} 7·60	10·10	} 48·84	15·57
Al_2O_3	=	1·29		3·83		} 4·00
Fe_2O_3	=	2·72		2·19		
MgO	} not det.			0·65		
CaO				0·15		

The oxygen ratio of PbO : CuO : V_2O_5 : H_2O in the above analyses is in:

a	=	2·97	:	2·89	:	6·41	:	6·59
b	=	3·60	:	3·36	:	8·34	:	....
c	=	3·08	:	2·97	:	6·95	:	....
d	=	1·94	:	1·96	:	4·36	:	....
e	=	3·04	:	3·03	:	6·90	:	6·44
or a	=	1	:	0·97	:	2·16	:	2·19
b	=	1	:	0·93	:	2·31	:	....
c	=	1	:	0·97	:	2·26	:	....
d	=	1	:	1·01	:	2·25	:	....
e	=	1	:	1	:	2·27	:	2·12

The average of the five analyses gives the ratio of

1	:	0·98	:	2·25	:	2·15
9	:	9	:	20	:	18

corresponding to—

$$3\,(3\,PbO, V_2O_5) + (3\,CuO, V_2O_5) + 6\,(CuO, H_2O) + 12\,H_2O.$$

giving the following percentage:

PbO	=	53·15
CuO	=	18·95
V_2O_5	=	19·32
H_2O	=	8·58
		100·00

Psittacinite occurs, sometimes associated with gold, and small quantities of cerussite, chalcopyrite and limonite upon quartz, at several of the mines in Silver Star District, Montana, especially in the Iron Rod Mine and New Career Mine, and its occurrence in these mines is looked upon as a favorable indication, for, when it is met with, the vein becomes immediately or soon after rich in gold. This mineral has been called "psittacinite" from psittacinus, siskin- or rather parrot-green.

University of Pennsylvania, Philadelphia, May 16th, 1867.

ART. VI.—*On a Disease of Olive and Orange Trees, occurring in California in the Spring and Summer of* 1875; by W. G. FARLOW, Assistant Professor of Botany in Harvard University.* With Plate III.

DURING the past summer, numerous complaints have come from southern California of a fungus which had attacked the olive and orange trees, and which was causing a considerable loss of those two crops. Our attention was first called to the subject by Dr. H. W. Harkness, who, in a letter from San Francisco dated May 11, sent a specimen of the fungus on an orange-leaf from southern California. Of the extent of the ravages of the fungus at that date no information has been received; but, as in a letter from San Diego, dated June 3, Mr. D. Cleveland† wrote that there was no trace of the fungus in that vicinity, we may suppose that the disease first appeared not far from Santa Barbara, where we have definite knowledge of its occurrence, and where great damage was done later in the summer. In a letter from Dr. George Thurber dated September 20, enclosing some specimens of the fungus, is the following from a correspondent in Santa Barbara: "We are troubled with our olive, lemon and orange trees. A small fungus appears on the leaves, twigs, and branches, at first visible only with a microscope, and of a green color. As it increases in size it turns brown, and then black. The olive is so exhausted that it is unable to fruit. The orange and lemon stand it better, but their fruit is so inferior as to be practically worthless." On the day of the receipt of Dr. Thurber's letter, another was received from Professor Dana, also enclosing specimens from Santa Barbara.

From the general tenor of letters from California, it is evident that, if this is not the first year of the appearance of the disease, it is, at least, the first in which it has attracted general attention; that its effect on the olive and orange crops has not been slightly, but markedly injurious; and that, in its advanced stages, there is present on the leaves and stems a blackish substance, which is universally regarded, by those who have formed any opinion on the subject, as a fungus. We have received, at different times, from California specimens of leaves and stems of orange and olive trees covered with the black growth, and have been able to study the fungus, which presents some points not without interest in a botanical point of view; and, if our conclusions do not point to a direct remedy, it will be conceded, we hope, that we have contributed toward removing some mis-

* Copied from the Bulletin of the Bussy Institution.

† We are in receipt of a letter from Mr. Cleveland, dated early in January, 1876, in which he sends specimens of the fungus on orange-leaves, which, he writes, is at that time common at San Diego.

conceptions as to the nature of the disease. At this distance, remote from all opportunities of observing the disease on living trees, there are, of course, some points in the development of the fungus which we have not been able to study; and our correspondence has not been sufficiently extensive or minute to enable us to give any statistics of the ravages of the disease, to ascertain the climatic or other changes which have preceded or accompanied the breaking out of the epidemic, or to decide whether it is the same form of disease which has been reported to occur in Florida. Our specimens present the disease as it appears when in a somewhat advanced stage, and after the leaves and stems have become so changed as to attract attention.

Mycelium.—The leaves of the olives which are affected by the disease are somewhat curled and shrivelled, and are of a browner color than normal leaves which have been gathered but a few weeks. On both surfaces of specimens sent us are black spots of greater or less extent, but in no case is the leaf perfectly black. On the upper surface the black spots are more numerous, more distinct in outline, and harder in substance, than on the lower, where they were more diffuse and of a powdery consistence. The twigs, of which we received only small specimens, are covered with spots which resemble more closely those on the upper than on the lower surface of the leaves. In one specimen the spots are nearly confluent, and the bark is visible in only a few places. After the leaves or stems have been soaked in water for a short time, the black substance can be scraped off without the least trouble, leaving the bark tolerably clean. The black substance, when seen with a magnifying power of four hundred diameters, is found to be composed of the stellate hairs peculiar to the olive, over which is growing a fungus, to the dark color of whose mycelium the spots owe their color. The mycelium is very variable in appearance. As a rule, it is composed of moniliform hyphæ, whose cells are ·006 mm. by ·008 mm., and in some places almost spherical. The color of the cell-wall is a dark or purplish brown, and in most of the cells there is a comparatively large-sized oil globule. These hyphæ branch in all directions, and the cells of the branches grow constantly longer, narrower, and paler, although, in all cases, retaining a tinge of brown. The relation of the mycelium to the stellate hairs and outer part of the twigs and leaves is clearly seen in cross sections. The hyphæ run along the surface of the epidermis and of the hairs, which it will be remembered resemble a broadly-opened, short-handled parasol. They are twined closely round the stems of the hairs, so closely, that the fungus cannot be removed without tearing them off. They do not enter into the cells of the olive, and there are no haustoria as in the case of some of the leaf parasites belonging

to the *Erysiphei*. Occasionally there are little knob-like projections of the cells which seem to indicate haustoria; but, by the most careful examination which we have been able to make, we have not been able to see that they enter into the cells of the stellate hairs or epidermis and act like haustoria. The surface of the hairs and epidermis, however, seems covered with a sticky substance (of which we shall have more to say hereafter), to which the hyphæ closely adhere. Plate 3, Fig. 2, shows one of the stellate hairs seen from below, with a portion of the mycelium growing upon it.

Various modifications of the mycelium are found principally on that portion growing on the outer part of the stellate hairs exposed to the air. After reaching a certain stage of development, they grow together in such a way that the hyphæ coming together laterally form a sort of membrane, as shown in Plate 3, Fig. 1, *d*. This membrane is composed of only one thickness of cells, but is very uneven as it follows and conforms to the inequalities of the hairs. Its general direction is parallel to the surface of the leaf or stem on which it is found.

Conidia.—The hyphæ, at their free ends, branch in all directions, and bear reproductive bodies of several kinds. The simplest form is that shown in Plate 3, Fig. 3, *d*, where the ordinary cells of the mycelium divide by cross partitions into two parts, which do not respectively grow to the same shape as the mother cell, but remain together two by two, as shown in the figure; the hypha becoming zigzag by the alternate lateral displacement of the pairs of cells, which finally drop off and readily germinate, each cell producing a germinal tube. In other parts of the mycelium, the terminal cell of certain threads divides by means of partitions, parallel to and at right angles to the axis of the filament, until a compound body is formed, which resembles the spores of the so-called genus Macrosporium. These bodies, which can only be described as irregular conglomerations of cells of an oval outline, are produced in great abundance and average ·015 mm. by ·025 mm., but are often much larger, though often smaller. They easily drop from their attachments and germinate, each cell being capable of producing a germinal tube. Other hyphæ, rising at right angles to the plane of the membranous portion of the mycelium, grow more and more attenuated, and branch at the tip; the terminal cells divide in two, as in Plate 3, Fig. 3, *c*, fall from their attachment, and germinate. This last modification of the hyphæ, which is by no means so common as the two previously described, will be recognized as corresponding to the so-called genus Helminthosporium, or Cladosporium, if we examine before the terminal cells have divided. It is out of the question to give specific names to such forms as those just described, which, since the

publication of Tulasne's "Carpologia Fungorum," are known to be different states of development of species of Pyrenomycetes.

Pycnidia.—Besides the forms already described, there are other bodies of a more complicated nature. Plate 3, Fig. 3, *a*, *a*, represents the *pycnidia*, which are quite numerous in the spots, both on the leaves and the stems. Their general shape is spheroidal. They consist of a membranous sac of the same color as the darker parts of the mycelium, in which are contained the small bodies, which are represented as being discharged in Fig. 3, *b*. Their average diameter is ·04 mm. In general appearance, the pycnidia resemble so closely those with which every one is familiar in other Pyrenomycetes, that any further description is unnecessary.

Stylospores.—In examining the larger black spots on the stems of the olive, other bodies are seen,—the *stylospores*, to adopt Tulasne's nomenclature. They are represented in Fig. 1, *a*, and resemble flasks, whose long necks project beyond the mycelium, by which they are surrounded. They may be recognized by the naked eye, and clearly seen with a hand-lens, as the black projecting necks are tolerably conspicuous. To obtain a good view of them, some of the larger black spots must be picked to pieces, and the fragments treated with caustic potash, and afterwards hydrochloric acid. The shape of the separate flasks is quite variable. The central portion of Fig. 1 represents one of the more regular, where, starting from a somewhat contracted base, there is a regular swelling of the central portion, which again diminishes into a rather long neck of uniform size. In some cases, the flask, instead of being straight, is flexuous with two swellings, the upper one being smaller than the lower. Others, still, fork, and usually one branch is much more obtuse than the other. The size of the flasks varies very much; but, even in their younger states, they can generally be distinguished from the pycnidia by being less inclined to a spherical shape. The height is as variable as the outline. Some of the smaller are ·15 mm. high; others—and they are nearer the average—are ·4 mm. The wall of the flasks is composed of dark-colored cells, which are longer in the direction of the axis of the flasks.

In some cases, the cells, composing the wall of the stylospores, grow outward, so as to form papillæ; and, as the mycelium at the base generally sends up branches around the flask, it is only by a careful dissection that the base can be clearly seen. At first, the mouth is closed, and there is a depression of the cells at the center; but, later, they spring back so as to form, round the open mouth, a circle of slightly reflexed teeth, whose tips are perfectly hyaline. The neck of the flask is hollow: but, in the swollen portion, spores are borne. They are oval, and divided

into four parts by cross partitions. They are not contained in asci, but are attached to short filaments which line the surface of the base and lower portion of the sides of the flask. They escape readily through the open mouth; and slight pressure on the covering-glass generally causes a fresh discharge.

So far, we have spoken of the fungus as seen on the olive. The orange-leaves sent us are also covered with a black substance, which is not so much in spots as in powdery sheets upon both surfaces of the leaves, more particularly the upper. The attachment to the leaf is by no means as strong as in the olive; and the deposit can easily be scraped off, even without previous moistening. In fact, in some places it falls off on the slightest touch. No specimens of diseased orange-stems were received for examination. A microscopic examination shows why the deposit was more easily removed from the orange than the olive leaves. The smooth surface of the former gives no permanent attachment to the fungus, which, as we have before said, does not penetrate into the interior of the cells of the mother plant; while, on the other hand, the hyphæ wind themselves tightly around the stalks of the stellate hairs of the olive, from which they cannot be removed. If the fungus should attack both oranges and olives, it is very evident why the latter would suffer much more than the former. Apart from the absence of hairs, which invariably constitute a large proportion of the scrapings of the olive-leaves, that from the orange-leaves is precisely identical,—the same moniliform hyphæ, bearing Macrosporium and Helminthosporium spore-like bodies, the same pycnidia and stylospores. Micrometric measurements only confirm the identity. On the orange-leaves sent me, there is a greater proportion of pycnidia, and a smaller proportion of stylospores, than in case of the olive-leaves; but that is, of course, an accidental difference, as the olive-leaves themselves vary. On the orange, the proportion of Helminthosporium-like spores is much greater than on the olive; but, from the facility with which the so-called secondary forms of fruit are produced in fungi, and their great variability, that it is not a fact of any importance; and we can in the most decided manner affirm that the fungus is the same on both plants.

The first account of a fungus growing upon orange-trees, resembling in its habits that received from California, was given by Persoon, in his Mycologia Europæa, p. 10, published in 1822. His description of the new fungus is very briefly given in the following words: "Fumago Citri, late effusa crassiuscula nigrogrisea. Provenit in Europa meridionali ad folia Citri Medicæ, quæ sæpe tota induit." Later, Turpin published an account, with a figure, of a species which he also called Fumago Citri, which Montagne made the type of a new genus, Capnodium,

published in the Annales des Sciences Naturelles, 3 série, tome 11, 1840. Montagne seems to have had doubts as to the identity of the Fumago Citri of Persoon with that of Turpin. Almost simultaneously with the publication by Montagne of his genus Capnodium, Berkeley and Desmazières published, in the Journal of the Horticultural Society of London, vol. iv, p. 252, an article "On some Moulds referred by Authors to Fumago." In this communication, there is the following description of the orange fungus briefly referred to by Persoon and Montagne: "Capnodium Citri, Berk. and Desm. Sparsum, setosum; peridiis elongatis; mycelio ramoso moniliformi pulcherrime reticulato; sporidiis oblongis minutis. Fumago Citri, Pers., Myc. Eur., vol. i, p. 10; Turpin, l. c. On leaves of different species of Citrus. France: Persoon, Léveillé."

Of fungi occurring on olive trees, we have an early account by Montagne in the Annales des Sciences Naturelles, 3 série, tome 12, 1849, of a fungus mentioned in the "Bull. Soc. Centr. d'Agric.," 2 série, iv, p. 267, under the name of Antennaria elæophila, which had been found at Perpignan in 1829, which caused ravages somewhat the same as the California fungus, and which had previously been referred by him to Cladosporium Fumago. It was probably the same plant as the Torula Oleæ of Castagne. Tulasne, however, in the "Carpologia Fungorum," vol. ii, p. 279, showed that the Freiesian genus Antennaria was the pycnidial state of species of fungi of which Capnodium was the ascigerous state. He restored the old name, Fumago, and gave a detailed account of Fumago salicina, which was illustrated in his unrivalled manner.

The fungus from California is evidently the same as that which has been known in Europe since 1829. We have examined two authentic specimens of Antennaria elæophila Mont.,—one from the Duby Herbarium, the other from that of De Notaris, and the structure is precisely that of the pycnidial-bearing portion of the California fungus. The stylospore-bearing portion of our fungus is the Capnodium Citri of Berkeley and Desmazières, to which they refer the Fumago Citri of Persoon and Turpin. Montagne had observed only the pycnidial form—his Antennaria elæophila—on olives; whereas, on the orange, he found only the stylospore form,—his Capnodium Citri. Berkeley and Desmazières make mention only of stylospores on species of Citrus. We have been so fortunate as to find, on the specimens from California, both pycnidia and stylospores, and on both olives and oranges,—which proves the identity of Antennaria elæophila (Mont) and Capnodium Citri (Berk. and Desm.) The perfect ascigerous state of the fungus we have not found; nor do Berkeley and Desmazières seem to have met with it, for they add to their description "asci have not been observed."

We have not been able to find any recorded instance of asci having been found in Capnodium Citri. Tulasne remarks,—quite pertinently, as it seems to us,—that, until better known, Capnodium Citri and Antennaria elæophila can scarcely be considered distinct from Fumago salicina.* The specimens from California certainly seem to strengthen Tulasne's suspicions; and we must confess ourselves quite unable to distinguish between Fumago salicina—found on willows, oaks, birches, hawthorn, quince, and pear—and Capnodium Citri, found on oranges, and, as the Californian specimens show, also on olives. If it be said that no asci have been seen by us, that is no reason why the fungus should be removed from Fumago salicina, which, in the conformation of its mycelium, its conidia, pycnidia, and stylospores, it most closely resembles. Evidently, in the group of fungi which we are considering, too much stress must not be laid on the length and shape of the stylospores. We see, in the specimens before us, how great is the variation in what is undoubtedly a single species. Neither is the fact of the branching of the stylospores very significant, as, in the present case, there are both simple and branching stylospores. If the reader will compare our Plate 3, Fig. 1, with that of *Fumago salicina*, by Tulasne, "Carp. Fung.," Plate XXXIV, Figs. 14 and 20,—leaving out of sight, as far as possible, the different artistic merits of the two,—we think he will admit that, in all essential particulars, they are alike. In reality, the resemblance is even greater than the limited size of our drawing would indicate. We have said that we found no asci; but Plate 1, Fig. 1, *c*, would seem to be the early stage figured by Tulasne, l. c. Fig. 20. The asci will probably be found in California; and we do not doubt that they and their contained spores will prove to be like those of Fumago salicina.

If we seem to the reader to have gone too minutely into the consideration of the systematic position of the fungus, it was for the purpose of bringing out more forcibly the fact that it is nothing new, or peculiar to California; and that it is not even limited to orange, lemon, and olive trees, but, as we have seen, is found on a number of other trees. How does it happen, then, that a fungus so widely diffused should suddenly increase to such an extent as to injure two important crops? We remarked, in passing, that the hyphæ seemed to be, as it were, gummed to the stellate hairs, and, in some cases, to one another, by a sticky substance. We do not forget, that, when any mycelium is growing on a leaf, a certain amount of dirt—including, of course, some oily matter—is sure to be entangled in its meshes. In the

* "Donec melius cognoscantur, a Fumagine salicicola supra descripta ægre etiam discriminantur, nisi sede sibi singulis assueta, tum *Fumago Citri*, Persoonio seu *Capnodium Citri* Montanio; tum etiam *Antennaria elæophila*, Montanio," &c. (Selecta Fungorum Carpologia, pp. 283, 284.)

case of the present fungus, however, there is something more than an accidental accretion of such substances. The surface of the leaves and stems is in many places covered with a gummy deposit, presumably of insect, certainly not of fungus, origin. On this gum, the fungus grows luxuriantly; and, although it may be found on those parts of the leaves where no gum can be seen, yet it is evident that it has reached such places by growing from the gummy spots. Of the origin of the gum, other than that it does not come from the fungus, we have no theory of our own to advance. Remains of insects are abundant on the leaves; but, being entirely ignorant of entomology, we cannot say what their relation is to the diseased trees. It may be that they are stray visitors caught in the gum. The fungus grows most luxuriantly on the remains of insects which I have seen, which, in some cases, present a ludicrous spectacle, the hyphæ projecting from them like the quills of a hedgehog.

It has often been asserted by botanists that fungi, of the group to which ours belongs, are particularly inclined to attack trees which have been previously infested with insects. In 1849, Berkeley, in the London Journal of Horticulture, described a fungus occurring in Ceylon on coffee,—*Triposporium Gardneri*,—which followed the appearance of a species of coccus which was described in the same journal by Mr. George Gardner. In their paper on moulds referred to Fumago, Berkeley and Desmazières make the following statement: "They are often, if not always, preceded by honey-dew, whether arising from aphides, or from a sugary excretion from the leaves themselves. Frequently, too, they are accompanied by some species of coccus, especially in the genus Citrus." Tulasne * does not agree with the writers just mentioned, as will be seen by the reference. He begins his description of Fumago salicina, however, with the following words: "Initio fungillus e membranula constat tenuissima, alba, et hyalina, matricique vivæ instar gummi soluti illitus hæret, quamvis ab eadem, maxime si fortuito ea aruerit, frustulatim aliquando secedat. Id cuticulæ struunt utriculi, perexigui, . . . oleo pallido tandem repleti," &c. This initial stage described by Tulasne is figured in Table XXXIV, Fig. 2, mm., l. c. We must confess that the expression "matricique vivæ instar gummi soluti illitus hæret," seems a little indefinite, but the figure looks

* Quibusdam observatoribus visum est *Fumagines* in fructicibus potissimum provenire quos aphides primum occupassent, tamquam si ex humore dulci quem bestiolæ istæ emittunt, aut ex latice viscido quem matrix ab iis læsa copiosum aliquando stillat, suum pabulum traherent; necessitates autem hujus modi duplici de causa minime verisimiles censemus. Hinc enim sexcenties nobis contigit *Fumagines* luxuriantes videre in arboribus, omnis aphidum generis prorsus expertibus; illinc *Fumagines* vere parasitari constat, succis scilicet alienis uti ex his vivis. Super hoc argumento conferas tamen quæ attulit Berkelæus in tomo iv. (1849) Ephemeridis Soc. Hortic. Londinensium, nec non Georgio Gardner commentatiunculam ibidem (pp. 1–6) editam circa the Coffee-bug and Coffee-mildew. (Carp. Fung., ii, p. 280.)

exceedingly like a collection of oil-globules, or very small eggs. We do not pretend to say that what Tulasne saw was not a membrane of vegetable substance,—a part of the fungus itself; but, in the Californian specimens, we had something which looked very much like the mm. of Tulasne's figure, and, in this case, we have satisfied ourselves, by observation and experiment, that it is of animal nature, and not a part of the fungus, which, instead, was growing upon it. It is a little difficult to understand, from what is already known of the developement of fungi, how any fungus could begin as a very thin membrane, composed of small cells filled with oil. The initial stage of fungi, if we except the Myxomycetes, as far as we know, is filamentous, not membranous.

The result of our examination of the diseased orange and olive leaves is briefly as follows: The disease, although first attracting the eye by the presence of a black fungus, is not caused by it, but rather by the attack of some insect, which itself deposits some gummy substance on the leaves and bark, or so wounds the tree as to cause some sticky exudation, on which the fungus especially thrives. It is not denied that the growth of the fungus greatly aggravates the trouble already existing, by so encasing the leaves as to prevent the action of the sunlight; we only say, that, in seeking a remedy, we are to look further back than the fungus itself,—to the insect, or whatever it may be, which has made the luxuriant growth of the fungus possible. With regard to the fungus, we are able to assert that it is the same on both olives and oranges,—the species described by Berkeley and Desmazières under the name of *Capnodium Citri*, which seems to us, together with the pycnidial state described by Montagne under the name of *Antennaria elæophila*, to be but two states of a species identical with that described by Tulasne as *Fumago salicina*. It remains yet to find the asci on olives or oranges, which will probably be accomplished without difficulty in California. The earliest stages of the fungus should be studied by some one living near orange groves; for, although the disease has been known to attack greenhouse plants, it is not very common, or, in that case, so favorable for study. Especially is it to be desired that careful notes of the extent and manner of appearance of the disease, and the climatic and hygrometric conditions attending it, should be carefully recorded.

As a remedy, alkaline soaps, as strong as the trees will bear, will no doubt prove advantageous in case of the oranges; but, in the case of the olives, much less good is to be expected, owing to the presence of the stellate hairs on leaves and twigs. With this, our notice of the disease from a botanical stand-point ends; and we commend the subject to the attention of entomologists.

ART. VII.—*On the Reaction of Sulphuric Acid upon Tri-calcic Phosphate*; by H. P. ARMSBY.

THE following experiments were undertaken to ascertain the influence of temperature and time on the reaction between one molecule of sulphuric acid and one of tri-calcic phosphate.

The materials employed were precipitated tri-calcic phosphate and a solution of sulphuric acid containing in 1 c.c., 0·8784 grms. H_2SO_4.

The tri-calcic phosphate was prepared by precipitation from an ammoniacal solution of calcium chloride by di-sodic phosphate, the precipitate being washed with cold water. An analysis gave:—

Ca	33·73 per cent.
PO_4	53·82 " "
H_2O	not determined.

Although washed by decantation till the washings gave no precipitate with silver nitrate the substance still contained traces of soluble phosphoric acid, probably as phosphate of soda.

The experiments were conducted as follows: a weighed quantity (generally about five grms.) of tri-calcic phosphate was mixed by rubbing in a mortar with the equivalent quantity of sulphuric acid, and treated as follows:—

I.	Stood	2½	hours	at 100° C.		
II.	"	"	"	" ordinary temperature.		
III.	"	"	"	"	"	"
IV.	"	½	hour	"	"	"
V.	"	5	minutes at	"	"	

The mixture was then washed with cold water till the washings ceased to show an acid reaction, the filtrate diluted to 500 c.c. and in it lime, phosphoric acid, and sulphuric acid determined. The composition of the insoluble portion was in some cases determined directly, and in others by difference. In calculating the results, the sulphuric acid of the aqueous solution was combined with lime, the residue of the lime with phosphoric acid to mono calcic phosphate, and the remainder of the phosphoric acid was considered as free. A portion of it at least may have been the soluble phosphoric acid of the tri-calcic phosphate. In the insoluble portion the sulphuric acid was also combined with lime, and the remainder of the lime with phosphoric acid, the excess of the latter over that required to form tri-calcic phosphate being considered to exist as the only other insoluble compound, viz., di-calcic phosphate. The following table gives the results calculated on ten grams of $Ca_3(PO_4)_2$.

APPLIED.	I.	II.	III.	IV.	V.
$Ca_3(PO_4)_2$	10·000 grms.	10·000 grms.	10·000 grms.	10·000 grms.	10·000 grms.
H_2SO_4	3·143 "	3·748 "	3·209 "	3·209 "	3·209 "
FOUND, soluble.					
$CaSO_4$	2·124 grms.	2·459 grms.	2·960 "	1·140 grms.	
$CaH_4(PO_4)_2$	·837 "	1·277 "	1·334 "	·850 "	3·562 grms.
H_3PO_4	·309 "	·343 "	·152 "	·448 "	
Insoluble.					
$CaSO_4$	2·168 grms.	2·784 grms.	1·504 grms.	3·466 "	
$CaHPO_4$	6·467 "	6·120 "	5·415 "	5·493 "	
$Ca_3(PO_4)_2$	1·065 "	·803 "	1·899 "	1·947 "	

It will be seen that the amount of di-calcic phosphate increases and that of mono-calcic phosphate decreases the longer the mixture stands and the higher the temperature to which it is exposed.

The following table shows the decrease of mono-calcic phosphate still more clearly.

If the reaction take place according to the equation

$$Ca_3(PO_4)_2+2H_2SO_4=CaH_4(PO_4)_2+2CaSO_4$$

one molecule of sulphuric acid should render soluble one molecule, or its own weight, of phosphoric acid. The fourth line of the table gives the per cent of this theoretical quantity which was actually found.

	I.	II.	III.	IV.	V.
Applied, $Ca_3(PO_4)_2$	2·784 grms.	2·972 grms.	4·377 grms.	4·377 grms.	4·377 grms.
" H_2SO_4	·875 "	1·113 "	1·405 "	1·405 "	1·405 "
Found H_3PO_4	·282 "	·420 "	·555 "	·507 "	1·305 "
% of theoret. H_3PO_4	32·2 %	37·7 %	39·5 %	36·1 %	92·8 %

In order to be sure that these differences were not due to incomplete washing a second set of experiments was made with smaller quantities. The tri-calcic phosphate was mixed with water to a thin paste, the sulphuric acid added, the mixture well stirred, and treated as follows:—

I. Stood 3 hours at 100° C.
II. " " " " ordinary temperature.
III. " ½ hour " " "
IV. " 5 minutes at " "

It was then filtered on the pump, washed with cold water till the washings showed only a very faint reaction for phosphoric acid with magnesia mixture, the filtrate diluted to 500 c.c. and in 50 c.c. the phosphoric acid determined by the molybdic method.

	I.	II.	III.	IV.
Applied, $Ca_3(PO_4)_2$	1·751 grms.	1·751 grms.	1·751 grms.	1·751 grms.
" H_2SO_4	·438 "	·438 "	·438 "	·438 "
Found, H_3PO_4	·172 "	·200 "	·209 "	·415 "
% of the theoretical H_3PO_4	39·2 %	45·6 %	47·7 %	94·7 %

To ascertain the extent of error from incomplete washing the insoluble portion of I. was further washed with about 250 c.c. of cold water and the phosphoric acid in the filtrate determined.

Its amount was 0·013 grms. a part of which was doubtless due to di-calcic phosphate which is slightly soluble in water, though not sufficiently so to introduce any material error into the experiments.

From the above results it appears that the reaction between sulphuric acid and tri-calcic phosphate, when the two are present in the proportion of one molecule of each, passes through two stages.

1st. The sulphuric acid reacts on half the tri-calcic phosphate, producing mono-calcic phosphate. Whether free phosphoric acid is at first produced cannot be determined from these experiments, but if it is, it must quickly disappear.

2d. The mono-calcic phosphate thus produced reacts more slowly on the other half of the tri-calcic phosphate in the manner described by Piccard (Zeitschr. für Chemie, ix, 545), producing di-calcic phosphate,

$$CaH_4(PO_4)_2 + Ca_3(PO_4)_2 = 4CaHPO_4.$$

A high temperature appears to favor the reaction.

Chemical Laboratory of the University of Leipzig, March, 1876.

ART. VIII.—*Dr. Vogel's Color Theory;* by M. CAREY LEA, Philadelphia.

WHEN Dr. Vogel first endeavored to establish the existence of a relation between the color of substances modifying the sensitiveness of silver bromide and the refrangibility of the rays to which that sensitiveness was increased, I made a two-fold objection. First, that no sufficient proof had been given that in any one instance a colored pigment had increased the sensitiveness to the rays which it absorbed. Second, that many substances altogether colorless conspicuously increased the sensitiveness to particular rays. To this last objection Dr. Vogel replied that because substances were colorless, it did not follow that they acted equally upon the different rays.

To give this answer weight, it should have been accompa-

nied by proof that some of these colorless substances showed a power of absorbing the rays to which they increased the sensitiveness of silver bromide. No such proof was given. Although scarcely called upon to prove a negative, yet desiring to leave no side of this question unexamined, I have recently subjected to careful spectroscopic examination those colorless substances which I have described as distinctly increasing the sensitiveness of silver bromide to green light.

This examination was made with a table spectroscope furnished with an exterior prism to throw light from a second source of illumination upon the slit, in order to obtain two adjacent spectra. The solution being then interposed in the path of one set of rays, the spectrum influenced by it is seen side by side with a complete spectrum, and the slightest changes are made evident. For greater exactness the glass vessel was first filled with water and interposed, then the argand burners used were moved to such distances as to make the two spectra exactly equal in intensity. In the examination, the size of the slit was varied from that which barely gave a visible spectrum, up to such as gave a powerful illumination, and the comparison was made with all intensities, though of course the faint illuminations gave the most critical tests. The substances examined were potassic arsenite, codeia, salicine and morphia acetate. All of these substances, as I have elsewhere shown, exhibit a marked power of increasing the sensitiveness of silver bromide to the green rays.

No elective absorption could be detected in any of them. It is therefore certain that *their capacity to increase the action of the green ray is independent of any power to absorb that ray.*

Certainly if a law such as enunciated by Dr. Vogel existed, there ought to be found, without difficulty, very many substances which would exemplify it. On the contrary Dr. Vogel has named very few cases in which he has recorded results conforming to his hypothesis. Indeed his hypothesis has seemed to rest chiefly upon three substances, coralline, chlorophyll, and naphthaline red.

I have very carefully examined the action of all three of the substances with the following results:

Coralline, as I have before said, enhances the sensitiveness more to the color which it chiefly transmits, red, than to those which it absorbs. Moreover its power of increasing sensitiveness (at least as far as the green rays are concerned) may be destroyed by the addition of a trace of weak acid, so that while its color remains, its action is destroyed. Coralline therefore does not afford any support to the theory, but rather the contrary.

Chlorophyll is perhaps the only substance that corresponds to some extent in its action with the demand of the theory. Some chlorophyll, which I prepared from ivy leaves, had a bright green color in solution; it diminished the action of silver bromide to the green rays, and increased it to the red. It should be said however that the support given by this substance is very much qualified by its peculiar absorption spectrum.

Naphthaline red has been cited by Dr. Vogel as affording by its action a powerful confirmation of his views. It has not done so in my hands.

When a not too strong solution is examined in the spectroscope, it is found to allow all the red and yellow rays to pass up to the limit of the green, where the transmission stops. Dr. Vogel affirms that the naphthaline red increases sensitiveness to the *yellow* rays, using it in not too strong solution. But it is certain that this substance unless it is used in very strong solution, allows the yellow rays to pass freely, stopping only the green and the rays beyond the green. It appears, therefore, that a dilute solution of naphthaline red *does not absorb* the yellows rays, to which, according to Dr. Vogel, it increases sensitiveness. And again the result of experiments made by myself with the green rays, which it does undoubtedly absorb, is that it not only does not increase sensitiveness to them, but actually diminishes it.

I therefore conclude that up to the present time no proof of the correctness of this theory has been found, but, on the contrary, a vast array of facts that are irreconcilable with it.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the true Ethyl Sulphate.*—By acting on ethyl alcohol or ether by sulphuric acid, Wetherill obtained a neutral body which has been regarded since that time as the true sulphuric ether, $SO_2 \left\{ \begin{matrix} OC_2H_5 \\ OC_2H_5 \end{matrix} \right.$. Later Baumstark obtained a substance by acting on alcohol by sulphuric oxychloride, which he supposed identical with Wetherill's ether, but which Max Müller regarded as an isomer of it, ethyl oxyethansulphonate, $C_2H_4 \left\{ \begin{matrix} OH \\ SO_2OC_2H_5 \end{matrix} \right.$. Mazurowska has prepared anew this latter compound, and has examined it more thoroughly. It appears as a yellowish, odorless, neutral liquid, of syrupy consistence and having a sp. gr. of 1·24. It dissolves readily in water, decomposing and becoming acid. Heated above 100° it carbonizes. Analysis gave it the formula

$(C_2H_5)_2SO_4$. Decomposition by water gave sulphethylic acid, the barium and potassium salts being prepared and analyzed. Methyl, propyl, butyl, and amyl alcohols yielded similar ethers, having analogous properties and forming a regular series. Wetherill's ether, however, is markedly different in its properties. It is an oily, colorless liquid, with an odor like peppermint, of sp. gr. 1·12, and which can be distilled, oily drops passing over at 110° to 120°. To ascertain which of these bodies was the true ether, the ethers themselves as well as the acids derived from them, were treated with potassium sulphydrate. In this way, Baumstark's body was proved to be the true ethyl sulphate, Wetherill's being its isomer as above. Similar ethers were obtained with phenol, nitro-phenol and thymol.—*J. pr. Ch.*, II, xiii, 158, March, 1876. G. F. B.

2. *Anthraflavic and Isoanthraflavic acids.*—Schunk and Roemer have detected in crude artificial alizarin a new acid, isomeric with anthraflavic acid discovered by the former chemist in 1871. To obtain it the crude alizarin is treated with lime water and the red solution decomposed with hydrochloric acid. The precipitate is dissolved in dilute soda solution, again precipitated, dissolved in baryta water, and thrown down a third time. The yellow or green flocks crystallize from alcohol in yellow needles, sometimes in gold-yellow brilliant plates. Analysis of the substance dried at 150° gave the formula $C_{14}H_8O_4$; the crystals have a molecule of water. The salts of the new acid were prepared and analyzed, and compared with those of anthraflavic acid. These as well as the substitution derivatives showed marked differences between the two bodies. Both, it should be remembered, are isomeric with alizarin.—*Ber. Berl. Chem. Ges.*, ix, 378, March, 1876. G. F. B.

3. *On Sulphonaphthalide.*—Cleve has examined the substance obtained by Berzelius in 1837 by the action of sulphuric acid on naphthalene, and which he called sulphonaphthalide. Crystallized from absolute alcohol, it appears in perfectly white needles, often some centimeters long. It melts at 175·5°, is insoluble in water, difficultly so in alcohol and ether, very soluble in benzene. Analysis gives it the formula $C_{20}H_{14}SO_2$, or $SO_2\left\{\begin{matrix}C_{10}H_7\\C_{10}H_7\end{matrix}\right.$. Heated with phosphoric chloride and with ammonia, it yields a mixture from which ether extracts a solid body β-chloronaphthalene, $C_{10}H_7Cl$, leaving, behind the amide of β-naphthylsulphurous acid, the chloride being $C_{10}H_7SO_2Cl$.—*Bull. Soc. Ch.*, II, xxv, 256, March, 1876. G. F. B.

4. *Evolution of Hydrogen by the action of Zinc upon neutral Copper sulphate.*—For the preparation of a considerable quantity of finely divided copper by Schiff's method, Lothar Meyer heated to 60° C. a mixture of copper sulphate crystals, metallic zinc and water, and observed a rapid evolution of pure hydrogen, a fact noted in 1840 by Leykauf. Further experiments showed that the evolution of hydrogen takes place at ordinary tempera-

tures, but is very slow, continuing for months. The resulting solution contains only normal zinc sulphate, no basic salt being present. A dark gray powder is deposited, however, which consists of basic zinc sulphate and copper. It appears therefore that the copper in this reaction is not simply exchanged for zinc, atom for atom, but that some of the copper is replaced by hydrogen. This, giving hydrogen sulphate, is acted on by the zinc, evolving hydrogen.—*Ber. Berl. Chem. Ges.*, ix, 512, April, 1876. G. F. B.

5. *Decomposition of Ammonium nitrate by heat.*—BERTHELOT has studied the decomposition of ammonium nitrate by heat. He finds that this salt melts at about 152° C., but that no appreciable quantity of gas is evolved below 210°. The rapidity of the evolution increases uniformly with the rise in temperature up to 300°, and then, if the fire be urged, the mass explodes. These characters are those of an exothermic decomposition and sustain the results of the author's calorimetrical experiments, according to which the production of the hyponitrous oxide theoretically disengages, in the reaction $NH_4NO_3 = N_2O + (H_2O)_2$, about +46 calories. The volume of gas obtained, however, is always less than that indicated by theory, owing to the volatility of the ammonium nitrate itself. Indeed this salt may even be sublimed without decomposition by placing it, previously melted, in a capsule covered with paper, and over which is a card-board cylinder filled with fragments of glass. The capsule is placed in a sand bath and heated to 190° to 200°; the sublimed salt attaches itself in brilliant crystals to the sides of the capsule and the paper cover, a portion also passing through and covering the glass. Its composition was verified by analysis. That this is not a dissociation into ammonia and nitric acid is shown by the fact that the paper is not attacked.—*C. R.*, lxxxii, 932, April, 1876. G. F. B.

6. *Additional facts concerning Gallium.*—BOISBAUDRAN, the discoverer of gallium, has presented to the Academy a specimen of what he believes to be the nearly pure metal. The specimen weighed about one decigram and was extracted from 431 kilograms of the crude material. Unlike the specimen first made, and which was solid owing to impurities, the author finds pure gallium to be essentially a liquid metal, since it melts at 29·5°, and is therefore easily liquefied between the fingers. It exhibits markedly the phenomenon of surfusion, a globule remaining liquid for weeks, during which time the thermometer may go down to zero. Once solidified, the metal is hard and resistant; though easily cut and somewhat malleable. When melted it adheres strongly to glass forming a whiter mirror than mercury. Heated to redness in the air, it oxidizes only superficially and does not volatilize. It is not sensibly attacked by cold nitric acid. Its density is 4·7 at 15°. Deposited on platinum by electrolysis from solution in ammonium or potassium hydrate, it presents a grayish-white mat surface, formed of minute globules. Cold dilute hydrochloric acid dissolves it, disengaging hydrogen; but the residue obtained by evaporating this solution, is not colored by potassium

iodide, ammonia, or ammonium sulphydrate.—*C. R.*, lxxxii, 1036, May, 1876. G. F. B.

7. *Metallic Cerium, Lanthanum, and Didymium.*—Drs. Hillebrand and Norton, in Bunsen's laboratory, have obtained, by the electrolysis of the cerium, lanthanum and didymium chlorides, the metals in quantities sufficient for careful investigation. As proof of the purity of the materials employed they refer to the methods of separation given by Bunsen (Pogg. Ann., clv, 366). Metallic cerium has the color and luster of iron; it slowly tarnishes in dry air and in moist air soon changes color, as steel does when heated, to yellow, blue, and gray. After fusion it has the hardness of calcite, and is malleable and very ductile. The specific gravity of the electrolytic metal is 6·628, and after fusion under salt and potassium chloride it is 6·728. The low specific gravity found for cerium reduced by sodium 5·5 indicates that it contained sodium. The melting point of cerium is lower than that of silver and considerably higher than that of antimony. Its kindling temperature in air and oxygen is much lower than that of magnesium. Pieces scratched off inflame, and the wire ignited in a flame burns more brilliantly than magnesium wire. It burns when heated in chlorine, less readily in bromine vapor, and without incandescence in iodine vapor. Water at common temperatures is slowly decomposed by it; cold concentrated sulphuric acid and cold red fuming nitric acid do not attack it, but these acids when dilute, and also hydrochloric acid, dissolve it. Metallic lanthanum is much like cerium in its general chemical deportment, but by concentrated nitric acid it is easily attacked. It is slightly harder and less ductile than cerium; it is less permanent in air, and even in dry air its color soon changes to a steel blue. The specific gravity of a piece deposited by electrolysis weighing 7·6 grams was 6·163; after fusion it was less, 6·049. Its melting point appears to be near that of cerium, and its kindling temperature is higher. Small pieces from filing or striking on flint do not ignite spontaneously in the air, but burn brilliantly in the flame. Their analysis shows less than one per cent of impurity in the specimen.

Metallic didymium is more like lanthanum than cerium; it is not less lustrous, ductile or permanent in air than lanthanum, and has about the same hardness; its color is not as white, and moist air turns it yellow. Fine particles of the metal do not ignite spontaneously in the air, but burn when heated in a lamp flame. It is less fusible than either lanthanum or cerium, and the metal after fusion has a specific gravity of 6·544.—*Pogg. Ann.*, clv, 633, Aug., 1875. G. F. B.

8. *On Gentisin.*—Hlasiwetz and Habermann have published a second paper on Gentisin, a crystallized non-nitrogenous body obtained from gentian root (*Gentiana lutea*). In their previous paper they showed that under the influence of alkali hydrates, gentisin splits up into phloroglucin $C_6H_6O_3$ and an acid of the formula $C_7H_6O_4$, to which they gave the name gentisic acid.

Under the action of heat, this latter body loses carbon dioxide and yields a neutral body of the composition $C_6H_6O_2$, provisionally called pyrogentisic acid. They now find that this last substance is identical with hydroquinone, the true melting point of which is 169°, and that gentisic acid is identical with oxysalicylic acid, which fuses at 196° to 197°. From its reactions therefore the authors give to gentisin the rational formula

$$\begin{array}{l} C_6H_2\left\{\begin{array}{l}CH_3\\ O>\\ O\end{array}\right. \\ \ | \\ CO \\ \ | \\ C_6H_3\left\{\begin{array}{l}OH\\ OH\end{array}\right.\end{array}$$

and suppose that it is formed from an isomer of piperonal united to phloroglucin, thus:

$$C_6H_2\left\{\begin{array}{l}CH_3\\ O>\\ O\\ CO\,\vdots H\end{array}\right. + C_6H_3\left\{\begin{array}{l}OH\\ OH\\ \boxed{OH}\end{array}\right. - H_2O = \begin{array}{l} C_6H_2\left\{\begin{array}{l}CH_3\\ O>\\ O\end{array}\right. \\ \ | \\ CO \\ \ | \\ C_6H_3\left\{\begin{array}{l}OH\\ OH\end{array}\right.\end{array}$$

Hence when it is fused with alkalies, it acts thus:—

$$\underset{\text{Gentisin.}}{(C_{14}H_{10}O_5)_2}+O_2+(H_2O)_4=\underset{\text{Phloroglucin.}}{(C_6H_6O_3)_2}+\underset{\text{Oxysalicylic acid.}}{(C_7H_6O_4)_2}+\underset{\text{Acetic acid.}}{C_2H_4O_2}$$

—*Liebig's Annalen*, clxxx, 343, March, 1876. G. F. B.

9. *On the milky juice of an Asclepiad, Cynanchum acutum.*—Butlerow has examined the milky juice of Cynanchum acutum, brought from the Oxus by the Russian Geographical Society's Expedition. The plant is a climber and is regarded as poisonous, especially to camels. The juice contained a volatile non-poisonous alkaloid, and the aqueous portion was rich in potassium chloride, but contained no sodium though grown on a soil rich in that substance. Below the aqueous portion was a white coagulum, which fused by heat and evolved an odor like that from burning rubber. It was extracted with boiling alcohol and then with carbon disulphide. The latter left on evaporation a transparent yellow resin. The alcoholic solution deposited warty grains on cooling, which when purified crystallized in needles. On analysis this body gave the formula $C_{15}H_{24}O$, and as it appears analogous to the phenols in its properties, the author gives it the name cynanchol; the asclepion of List being an impure variety.—*Liebig's Ann.*, clxxx, 349, March, 1876. G. F. B.

10. *On Amidines of Monobasic Acids.*—The name amidine was given first by Wallach to a class of organic bases of the general formula $R.C\left\{\begin{array}{l}NR''\\ NR'_2\end{array}\right.$ derived from amides $R.C\left\{\begin{array}{l}O\\ NR'_2\end{array}\right.$ by exchanging O for $(NR)''$. As R represents either hydrogen or a hydrocarbon radical, it is evident that a series of bases may be formed from the amide of any acid in this way. Thus from acetamide

$CH_3C\genfrac{}{}{0pt}{}{\diagup NH_2}{\diagdown O}$	$CH_3C\genfrac{}{}{0pt}{}{\diagup NHC_2H_5}{\diagdown O}$	$CH_3C\genfrac{}{}{0pt}{}{\diagup NHC_6H_5}{\diagdown O}$ we have
Acetamide.	Acetethylamide.	Acetanilide.
$CH_3C\genfrac{}{}{0pt}{}{\diagup NH_2}{\diagdown NH}$	$CH_3C\genfrac{}{}{0pt}{}{\diagup NHC_2H_5}{\diagdown NC_2H_5}$	$CH_3C\genfrac{}{}{0pt}{}{\diagup NHC_6H_5}{\diagdown NC_6H_5}$
Acediamine (the amidine of acetamide).	Ethenyl-diethylamimide.	Ethenyldiphenylamimide.

In the same way, guanidine is the amidine of carbamide or urea. Under the influence of water the acid amides are regenerated. BERNTHSEN has examined several new bodies of this class, phenyl-acetamimide $C_6H_5-CH_2-C\genfrac{}{}{0pt}{}{\diagup NH_2}{\diagdown NH}$, its mono-phenyl and mono-tolyl derivatives, benzenyl-monophenyl-amimide,

$$C_6H_5-C\genfrac{}{}{0pt}{}{\diagup NH_2}{\diagdown NC_6H_5},$$

and the diphenyl, mono- and di-tolyl derivatives.—*Ber. Berl. Chem. Ges.*, viii, 1575; ix, 429, March, 1876. G. F. B.

11. *On Fermentation;* by P. SCHÜTZENBERGER. [International Scientific Series. D. Appleton & Co., New York.]—This volume, although rather too technical for the general reader, gives to the student in a convenient form a *résumé* of the early and of the most recent researches on fermentation (alcoholic, lactic, butyric, etc.), and is a valuable addition to the International Scientific Series, of which it is the third volume on chemical subjects. The aim and plan of the International Scientific Series has already been alluded to in this Journal (vol. v, p. 241, 1875). It is not our purpose in the present instance to criticize the subject matter of the volume before us, but to call attention to some of the shortcomings of the English version.

The most serious error is, perhaps, the translation of "*matières hydrocarbonées*" by "hydrocarbons." On page 65 and following, and throughout the book sugar, cellulose and starch are spoken of as "hydrocarbons!" A mistake scarcely less serious occurs in the description of Schützenberger's process for determining dissolved oxygen (pages 108 and following). Here Schützenberger's "hydrosulphurous acid" and "hydrosulphite" are rendered, very properly, "hyposulphurous" and "hyposulphite," but no note or comment (except the symbol) tells us that the sodium hyposulphite thus indicated is not the common "hyposulphite of soda" which still in the arts and indeed generally bears the old name. On other pages hyposulphite is used in its former sense (instead of "thiosulphate" or other name). It would therefore seem that the mistake arose from ignorance or carelessness on the part of the translator.

Among other less important blunders it may be said that "*poudre de zinc*" is not "powdered zinc" but zinc dust (zincstaub); Sterry Hunt regarded the albuminoids as "nitriles" not

as "nitrites" (and as this mistake occurs in several places it can hardly be a printer's error); "*étant ramenée*" (page iii) should be rendered "reduced" and not "brought back," as it is a question of converting a cupric to a cuprous compound for the first time.

In a prefatory note the translator deliberately chooses to render "*invertir*," "*inverti*," etc. by "alter," "altered," etc., instead of the much more familiar "invert," "inverted," etc. It is probably also to the choice of the translator that we owe the terms "potass," "hydratation," "dishydratation," "magnesium subcarbonate," and "marine salt."

We may pass over various misprints, mentioning one only, by which a paragraph headed in the original "*Gaz Lumière*" appears with the heading "Gas-light" to the confusion of the reader. We may, however, criticize the constant use of the French words, with accents, to indicate the weights and measures of the metric system, and also the giving in every case the equivalent in English weights and measures (often to the third place of decimals) even where an approximate or relative number is mentioned. As a single instance, we read on page 111, "about 1 cub. centimètre of oxygen (·061 cub. in.) for each 10 cub. cent. (·61 cub. in.) of the solution."

It is most certainly to be hoped that the promised volumes of Wurtz, H. SteClaire Deville, and Berthelot will not suffer such treatment at the hands of translators as have Vogel and Schützenberger. As far as the reader is concerned, it is at present safer to procure the works in the original tongues; and thus one promise of the *International Series* fails to be fulfilled. W. R. N.

12. *Liquid Films.*—Dr. SONDHAUSS has extended the observations of Plateau on liquid films to the determination of the extent to which different liquids can be stretched in wire rings. He observed the lamellæ in closed vessels excluding external disturbances, measured with a balance their tension and with a manometer the pressure of bubbles on the enclosed air; he also measured the weight of such lamellæ and bubbles, whence their thickness might be inferred. With a simple contrivance consisting of a thin wire bent horizontally to an angle, and a straight wire placed across and drawn gradually away from the angle, it may be shown that all liquids may be stretched in lamellæ, and that different liquids may be compared in this respect. But Dr. Sondhauss prefers the circular wire rings, and compares (as to size) the films of forty-six different liquids. One film from a guillaja decoction, to which a little glycerine had been added, lasted over half a year.—*Nature*, xiv, 37. E. C. P.

13. *Law of Refraction.*—Prof. FOSTER, at a recent meeting of the Physical Society, exhibited and described an instrument for illustrating the law of refraction. It is founded on the well-known method of determining the direction of the ray after refraction by means of two circles described from the point of incidence as a center, the ratio of whose radii is the index of refraction. If the incident ray is projected to meet the inner circle, and through the point of intersection a vertical line be drawn, the line drawn from

the point of incidence to the point where this meets the outer circle is the direction after refraction. This principle is applied in making a self-adjusting apparatus as follows: A rod representing the incident ray is pivoted at the point of incidence, and projects to a point about four inches beyond. To its extremity is attached a vertical rod which slides through a nut in another rod also pivoted at the point of incidence. The lower extremity of the vertical rod is attached to a link, so fixed as to constrain it to remain vertical. By this means the two rods always represent respectively the incident and refracted rays, and the index of refraction can be varied by altering the position of the nut, through which the vertical rod passes, on the rod to which it is attached.—*Nature*, xiii, 535. E. C. P.

14. *Magnifying Glass.*—Mr. JOHN BROWNING has recently contrived a new form of simple magnifier which is thus described: The platyscopic lens is a triple combination, in which the chromatic and spherical aberrations are corrected by a central lens of dense glass. This lens is nearly three times as thick as the crown-glass lenses. The interior curves are almost hemispheres. The final correction for spherical aberration is made by altering the thickness of the dense glass lens. The three lenses are united by a transparent cement which has an index of refraction corresponding very nearly with that of glass. This prevents light being lost by reflection from the surface of the deep curves. The platyscopic lens is made of three powers magnifying respectively 15, 20 and 30 diameters. It possesses the convenience of the Coddington lens while its freedom from chromatic and spherical aberration renders its definition vastly superior. Its working distance is also much greater than that of any lens of equal magnifying power. This is very perceptible in the smallest of the series which gives so much space that opaque objects can be viewed with the greatest facility--an important matter to naturalists in field observations. A very good view is also obtained through water. Owing to the perfect corrections the internal diaphragm of the Coddington lens is not needed, causing a vast increase of light.—*Quart. Journ. of Sci.*, l, 284. E. C. P.

15. *New Electro-Magnet.*—M. V. SERRIN calls attention to the difficulty experienced with powerful electric lights from the heating of the magnets in their regulators. The effect of this is to burn the insulating material and destroy the effect of the magnet by short circuiting it. This difficulty is avoided by a metallic helix with no insulating covering and so formed that the spires cannot touch. The helices are made of copper cylinders of a thickness equal to that of the bobbin. The cores are then covered with a vitreous enamel. The construction of these helices presents no especial difficulty and has the advantages of beauty and that it is easily taken to pieces. The cross-section is such that the metal is not heated perceptibly to the touch with even a powerful Bunsen battery, while it may be heated to redness without undergoing sensible change or losing its efficiency. Some further improvements have been introduced into the regulator so that the luminous point may be moved without extinguishing it, a mat-

ter of great importance in light-houses. In the model the carbons are 15mms. on a side and yet notwithstanding their large size the sensibility of the apparatus is so great that a small ring of rubber placed between the two carbons is capable of arresting the motion without undergoing a sensible change in form.—*Comptes Rendus*, lxxxii, 1054. E. C. P.

16. *Electro-magnetic Rotations.*—Mr. W. Spottiswoode in a recent communication to the Royal Society discusses the phenomenon known as the rotating spark. A powerful magnet being brought near the spark the latter is seen to assume a spiral form which is right-handed or left-handed according to the direction of the current and of the magnetic polarity. The spark was passed between the poles of an electro-magnet and the effect on the form of the discharge caused by exciting the magnet was observed. For this purpose the movable poles were insulated from the main body of the magnet by interposing a sheet of ebonite thick enough to prevent the passage of the spark.

The discharge, as is well known, consists of two parts, the spark proper and a bright cloud or flame surrounding it which may be thrown to one side by a current of air. The spark is but little affected by the magnet, but the flame is at once spread out into a sheet forming a right or left handed helicoid according to the direction of the current, and following Ampère's law. Similar effects were obtained with other gases and at other pressures. The brilliancy may be increased by attaching a piece of sodium to the negative terminal, or by causing a stream of any of the volatile chlorides to flow across the field of action. The following explanation is due to Prof. Stokes. Supposing the magnetic field to be uniform, the lines of force will be straight lines from pole to pole. In such a condition everything being symmetrical, no rotation would take place. But if through any local circumstance the path of the current be distorted or displaced, then each element will be subject to two forces, one tending to turn the current around the axis, the other tending to make it follow the shortest path so as to diminish the resistance.

The general nature of the phenomenon may be described as follows: First, we have the bright spark of no sensible duration which strikes nearly in a straight line between the terminals. This opens a path for the continuous discharge which being nearly in a condition of equilibrium, though an untranslatable one, remains a short time without much change of place. Then it moves rapidly to its position of equilibrium, the surface which is its locus forming the sheet. Then it remains in its position of equilibrium during the greater part of the discharge, approaching the axis again as the discharge falls, so that its equilibrium position is not so far from the axis. Thus we see two bright curves corresponding to the two positions of approximate rest united by a less bright sheet; the first curve lies nearly in a straight line and the second nearly in a helix traced on a cylinder of which the former line is a generating line. The appearance of the discharge when viewed in a revolving mirror confirms the above remarks.—*Nature*, xiii, 698. E. C. P.

II. Geology and Mineralogy.

1. *Recent Discoveries of Extinct Animals by Professor Marsh.*—In a lecture to the Graduating Class of Yale College, delivered in the new Peabody Museum, June 3d, Professor O. C. Marsh gave a brief *résumé* of the more important results of his late paleontological researches in the Rocky Mountain region. His explorations, which were attended with much hardship and danger, have been mainly confined to the Cretaceous and Tertiary formations, and especially to their vertebrate fauna. During the past six years, the expeditions under his charge have brought to light more than 300 species of fossil vertebrates new to science, about 200 of which he has already described.

Among the extinct animals thus discovered, were many new groups, representing forms of life hitherto unknown. The most interesting of these are the Cretaceous *Odontornithes*, or Birds with teeth, which constitute a new sub-class, containing two distinct orders, viz: the *Odontolcæ*, which have the teeth in grooves, and the *Odontotormæ*, with teeth in distinct sockets. The former were swimming birds of gigantic size, with rudimentary wings, and the vertebræ as in modern birds. The type genus is *Hesperornis*, and three species are known. The second order embraces at present only small birds with powerful wings, and biconcave vertebræ. The type genus is *Ichthyornis*, and the geological horizon is upper Cretaceous. Another discovery of importance from the same formation was Pterodactyls, or flying reptiles, the first detected in this country. These are of much interest, on account of their enormous size,—some having a spread of wings of more than twenty-five feet,—but especially as they were destitute of teeth, and hence resembled recent birds. They form a new order, *Pteranodontia*, from the typical genus *Pteranodon*, six species of which are now known. With these fossils were found large numbers of Mosasauroid reptiles, and remains of more than 500 different individuals were collected. These proved to belong to two new families, *Tylosauridæ* and *Edestosauridæ*. Some of the former attained a length of sixty feet, while the latter were much shorter, the smallest being less than ten feet. These groups included several new genera and many species. This large series of specimens enabled Professor Marsh to clear up many doubtful points in the structure of these reptiles, and to determine that they possessed hind paddles, and were covered, in part at least, with bony dermal scutes. Many other Birds, Reptiles and Fishes were found in the same Cretaceous strata.

The discoveries of Professor Marsh and party in the Tertiary of the West were of no less importance. The most interesting are those made in the two Eocene lake-basins between the Rocky Mountains, and the Wahsatch Range. These basins were explored by Professor Marsh in 1870, and their Eocene age then

first determined. His explorations in this region have secured to science over 150 species of new vertebrates, most of them widely different from any hitherto known. The most remarkable of these are the gigantic mammals of the new order *Dinocerata*, the type genus of which is *Dinoceras*. These animals nearly equalled the Elephant in size, but the limbs were shorter. The skull was armed with two or more pairs of horn-cores, and with enormous canine tusks, similar to those of the walrus. The brain was proportionally smaller than in any other land mammal. Three genera and several species are known. Remains of more than 100 distinct individuals were obtained, and are now in the Yale Museum. The *Tillodontia* are another new order of mammals discovered in the same Eocene deposits. They possess many remarkable characters, which indicate affinities with the Carnivores, Rodents, and Ungulates. There are two well marked families, the *Tillotheridæ*, from the typical genus *Tillotherium*, which has Rodent-like incisors; and the *Stylinodontidæ*, in which all the teeth grew from persistent pulps. The largest of these peculiar animals was about the size of a Tapir. One of the most interesting discoveries made by Professor Marsh in the Eocene of Wyoming was the remains of Quadrumana, the first found in the strata of America. These early Primates appear to be related both to the Lemurs of the old world, and to some of the South American Monkeys. Two families are known, the *Lemuravidæ*, from *Lemuravus*, the principal genus, which has 44 teeth, and the *Limnotheridæ*, which have not more than 40. The latter group is rich in genera and species. Among the other Eocene Mammals discovered were Marsupials and Bats, not before known in a fossil state in this country. One of the most important Eocene Mammals found was a small ungulate, which is the oldest known ancestor of the horse. It was about as large as a fox, and had four toes before and three behind. The genus was named *Orohippus*, and several species were discovered. These remains, in connection with others from the later Tertiary, enabled Professor Marsh to trace the line of descent which has apparently produced the modern horse. In addition to the Eocene Mammals, many species of Birds, Serpents, Lizards, and other vertebrates were collected.

The discoveries made by the same expeditions in the Miocene and Pliocene lake-basins of the Rocky Mountains and Pacific coast were likewise very numerous, and many new forms of animal life were brought to light. One group of mammals found in the early Miocene of Oregon is allied to the modern *Rhinoceros*, but differs in having a transverse pair of horn-cores on the nasal bones. The genus was called *Diceratherium*, and one of its species is the oldest known member of the Rhinoceros family, if not its progenitor. The most remarkable mammals found in the Miocene were the huge *Brontotheridæ*, which are apparently allied both to the above group and to the Eocene *Dinocerata*. They equalled the latter in size, and had also an elevated pair of horn-cores on the maxillary bones. One genus of this family was previously known

by imperfect specimens. Besides *Brontotherium*, several other new genera of this group were found, represented by portions of over 200 individuals. With these remains was discovered a genus of small equines, *Mesohippus*, about as large as a sheep, and having three toes on each foot, with an additional "splint" bone on those in front, thus forming an interesting Miocene link in the genealogy of the horse, completed by the Pliocene genera. Over 30 species of fossil horses were collected in these formations. Among the interesting animals obtained in the Pliocene deposits were two species of large Edentates, the first Tertiary representatives of this order from America. They belong to a new genus, *Morotherium*. There were also found large numbers of Rhinoceroses, Camels, Suillines, and other mammals, as well as many Birds, Reptiles, and Fishes.

A study of the large series of extinct animals thus collected, and now in the Yale Museum, promises to throw much light on the development of life on this continent, and Professor Marsh has already drawn from them some important principles. One of these relates to the size and growth of the brain in Mammals, from the beginning of the Tertiary to the present time. The conclusions reached may be briefly stated as follows: *first*, All Tertiary mammals had small brains; *second*, there was a gradual increase in the size of the brain during this period; *third*, this increase was mainly confined to the cerebral hemispheres, or higher portion of the brain; *fourth*, in some groups, the convolutions of the brain have gradually become more complicated; *fifth*, in some, the cerebellum and olfactory lobes have even diminished in size. There is some evidence that the same general law of brain-growth holds good for Birds and Reptiles from the Cretaceous to the present time.

Some additional conclusions in regard to American Tertiary Mammals, so far as now known, are as follows: *First*, all the *Ungulata* from the Eocene and Miocene had upper and lower incisors; *second*, all Eocene and Miocene mammals had separate scaphoid and lunar bones; *third*, all mammals from these formations had separate metapodial bones.

In conclusion, Professor Marsh stated that his work in the field was now essentially completed, and that all the fossil remains collected, and in part described, were now in the Yale College Museum. In future, he should devote himself to their study and full description; and hoped at no distant day to make public the complete results.

2. *Report upon Geographical and Geological Explorations and Surveys west of the* 100*th Meridian*, in charge of Lieut. G. M. Wheeler, Corps of Engineers, U. S. Army. Published by authority of the Secretary of War.—The reports of the work done, up to the close of 1873, make six volumes: I. The Geographical Report; II. A Report on the Astronomy and Meteorology; III. On the Geology and Mineralogy; IV. On the Paleontology; V. On the Zoology; and VI. On the Botany. Besides these, there

are to be two atlases, one topographical and one geological. Volume III, and Part I of volume IV have recently been published.

Vol. III. *Geology*, 682 pp. 4to, with maps, sketches and sections. The geological reports, on portions of California, Nevada, Utah, Colorado, New Mexico and Arizona, making up this volume, are a record of good work and of valuable results. Two of the reports are by G. K. Gilbert, and one each by A. R. Marvine, E. E. Howell, J. J. Stevenson and Oscar Loew. Part of the observations and conclusions of Mr. Gilbert are brought out in an article by him, in this Journal, commenced on page 16 of this volume. They cover the subjects of orology, erosion, glacial phenomena, volcanic rocks, and the stratified rocks. All the reports, and especially Mr. Gilbert's, throw much light on the characters and dynamics of displaced and folded rocks,—a subject which the prevailing absence of soil and forest makes easy of investigation. The volume is illustrated by several fine plates of scenery along the valleys illustrating erosion, and one a case of "rain-sculpture" exemplifying admirably the origin of mountain forms.

Mr. Loew's report discusses the agricultural resources and soil of the regions examined in Colorado, New Mexico, and Arizona, gives analyses and descriptions of mineral waters and minerals, and describes the eruptive rocks.

Vol. IV. *Paleontology*, Part I. Report on the Invertebrate Fossils collected in portions of Nevada, Utah, Colorado, New Mexico and Arizona, by the expeditions of 1871–1874, by C. A. White, M.D., 220 pp. 4to, 1876.—After some general observations on the collections and the periods they represent, Professor White takes up the description of the fossils in the order of the formations, and illustrates the large number of species with twenty-one well-filled quarto plates. The fossils belong to the Primordial, Canadian and Trenton periods of the Lower Silurian; a few species to the Devonian; nearly half of all to the Carboniferous age, some of them Subcarboniferous, but the larger part of the Coal period; a few (eight) to the Jurassic period; many to the Cretaceous, and fifteen to the Tertiary. The Primordial animal fossils enumerated and described are *Acrotreta subsidua* White, *Trematis pannulus* White, *Hyolithes primordialis* Hall (?), *Agnostus intestrictus* White, *Conocoryphe Kingii* Meek, *Asaphiscus Wheeleri* Meek, *Olenellus Gilberti* Meek, *O. Howelli* Meek.—The beds of the Canadian period (Quebec Group) afforded him twelve species, among which are the Graptolite, *Phyllograptus Loringi* White, and the trilobites, *Megalaspis belemnurus* White, and *Dicellocephalus? flagricaudus* White. Four species of Graptolites are mentioned from the Trenton beds, *G. pristis?* and *G. quadrimucronatus?* of Hall, *G. ramulus* White, and *G. hypniformis* White. The Primordial fossils are from Antelope Spring, House Range, in Utah, from Pioche in Nevada, and from Ophir City, Oquirrh Range, in Utah; the Quebec fossils are from Fish Spring in House Range, and from Schellbourne and Queen Spring Hill in Schell

Creek Range in Nevada. Of Subcarboniferous species, five from a locality below Ophir City, are identical with Mississippi Valley species, of the Kinderhook group, *Strophomena rhomboidalis*, *Spirifer peculiaris*, *Sp. centronatus*, *Sp. extenuatus*, and *Terebratula Burlingtonensis*. Prof. White remarks on the similarity of the conditions in the coal-measure area over the Rocky Mountain region to those of the Subcarboniferous, and thus accounts for the close relations of the two in fossils. Of the coal-measure plants in the collection there is only a single specimen each of *Sigillaria* and *Neuropteris*, land plants being the rarest of fossils.

The descriptions of species throughout the work are well drawn up, and many points of general interest are brought out.

3. *Historical Sketch of Geological Explorations in Pennsylvania and other States;* by J. P. LESLEY, with an appendix, 200 pp. and xxvi pp. 8vo. Harrisburg, 1876.—Prof. Lesley's review of early American geological papers and explorations, constituting his chapter I, will be read with great interest. It is written with spirit and illustrates well the progress of geological ideas in the country, though laughing sometimes too heartily and inconsiderately we think over old errors incident to that progress.

Chapter II treats of the work of the short-lived "Geological Society of Pennsylvania," and "what it did to bring about the first geological survey of the State."

Chapter III gives a detailed history, geological and personal, of the first geological survey of Pennsylvania, and has special value since some of the most important principles now adopted in North American geology were then developed. In some cases, however, the views commended by the author are not those which most others would equally commend. For instance, this: "that existing mountains are the remains of a continent once standing at some easily determined higher level than the present continent;" and that this idea "has sent out of existence the old-time notions of mountains of elevation." The principle cited looks strange along side of the fact—one of many—that a large portion of the Rocky Mountain region was under salt water in the Cretaceous, and has since, some how, got up six to ten thousand feet above the sea-level. It involves an exaggerated use of one good idea at the expense of another of greater importance. But notwithstanding some such peculiarities, and the too great freedom of personal remark occasionally indulged in, American science is indebted to the author for the history.

4. *Second Annual Report of the Geological and Agricultural Survey of Texas;* by S. B. BUCKLEY, State Geologist. 96 pp. 8vo. Houston, Texas, 1876.—This report makes brief mention of some localities of the different rock-formations of the State, and treats more at length of the mineral and agricultural products. It is stated that in the valley of the Rio Grande, from six miles below Fort Quitman northward to El Paso, there are two and sometimes three terraces. The two upper consist of sand and gravel. The gravel is often filled with large water-worn quartz pebbles, and in

some places have a thickness of 100 feet or more; and for a large part of the way it is fifteen or twenty miles from the river. Veins of argentiferous galena are reported in the Organ Mountains, in El Paso County, and in the Chinati Mountain, Presidio County, (affording 16 to 76 dollars of silver to the ton); and five miles northeast of Mason in Mason County.

A mass of meteoric iron is contained in the State collections at Austin, weighing 315 pounds, which is said to have been found on the head waters of the Red River, northward of Young County.

5. *Primordial of Scandinavia.*—According to G. Linnarssen (Geol. Mag., April, 1876, p. 146, in a reply to a paper by Mr. H. Hicks), the oldest fossiliferous rocks of Scandinavia consist, in ascending order, of (1) the Eophyton sandstone; (2) the Fucoid standstone; and (3) the Paradoxides schists; and the last corresponds to the Harleck and Menevian groups of the British Lower Cambrian. The Paradoxides schists contain the Trilobite genera *Paradoxides* (*Anopolenus*, *Plutonia*), *Conocoryphe* (*Erinnys*), *Microdiscus*, *Arionellus*, *Agnostus*, and also *Leperditia*, *Hyolithus*, *Lingulella*, *Obolella*, *Orthis*, *Protospongia*, etc. The beds below the Paradoxides schists contain no trilobites. The Fucoid sandstone has afforded two species of *Lingulidæ*, and the Eophyton sandstone a number of species of *Brachiopods*, *Pteropods*, *Spongiæ*, besides the doubtful *Cruziana*, *Harlania* (*Arthrophycus*), *Eophyton*, etc. Forms like those of *Cruziana* and *Eophyton* have been found also at other horizons higher in the Silurian, and a Harlania much like the Primordial in the Rhætic beds of Scania. One of the Brachiopods of the lower beds of the Eophyton sandstone is the *Lingula* or *Obolus monilifer*, but it probably pertains to a new genus; and two other fossils are *Hyolithus lævigatus* and *Astylospongia radiata.* The thickness of the sandstone under the Paradoxides schists in Scandinavia is but a fifteenth of that of the corresponding beds in the English Cambrian; but this is no evidence that the former are younger than the latter.

The "Primordial zone" or stage C, of Bohemia is younger than the oldest fossiliferous strata of Scandinavia, and corresponds most nearly with the middle of the Paradoxides schists. That any identical species occur in both is not certain; but there are several that are closely related, as *Paradoxus Tessini* and *P. spinosus*, *Ellipsocephalus Hoffi* and *Agnostus rex.*

6. *Glacial flood.*—In a paper "on the Drift-deposits of the Northwest," in the Popular Science Monthly for July, 1873, Prof. N. H. Winchell presents the view that the terraces along the rivers and about the lakes of the Northwest [the northern part of the Continental Interior] are due solely to floods along the rivers and the lakes consequent on the melting of the great glacier. The investigations which I have made since the publication of his paper, and which are the subject of my recent memoir on Southern New England, have satisfied me that in this he is essentially right. Prof. Winchell argues, thence, against the opinion that the Champlain period was one of more or less depression of the

land over the higher latitudes of the Continent. But this conclusion does not necessarily follow, as is evinced by the facts over New England. When he says "the four-hundred-foot beach near Montreal may have had the same origin as the so-called beaches that rise several hundred feet higher in the State of Ohio," his language is ambiguous; but interpreting it by the context it is wrong, if we may trust Logan, Dawson, and others, who have studied those high St. Lawrence "beaches;" for these geologists describe them as true sea beaches and under-water marine deposits, containing *marine* shells, and some of the beds, as I know from examination, are full of such shells; and this they could not be if made by fresh water floods. The same is true of the elevated beaches on Lake Champlain, and of others on the Coast of Maine. Wherever such beaches occur they prove a depression of the land during the era of their formation; and their wide distribution leads to the natural inference that all northern New England participated in the subsidence. Such Eastern facts do not, however, *prove* that the Continental Interior, farther west, participated in the subsidence; and yet this may have been a fact. Whether so or not facts that will demonstrate the truth are difficult to find over the interior of a wide continent, and hence a uniform opinion among geologists may never be reached. J. D. D.

7. *On the Ice Age in Great Britain;* by RALPH RICHARDSON.—In this paper (Proc. Edinburgh Geol. Soc., 1876) the author gives the facts with regard to the shallow depths of ocean between Great Britain and Iceland and Greenland on one side and over the German Ocean on the other, and presents reasons for believing that there was dry land over the region in the Glacial era; that the Glaciers of Great Britain came over this emerged land from the north and west; and that the cold of the Glacial era was due in part at least to the closing thus of the Arctic, and excluding thereby the Gulf Stream. The facts appear to sustain the conclusions. The depth between Britain and Iceland mostly does not exceed 100 fathoms, and no where exceeds 1,000; and one tract of sea extending in a straight line from the eastern coast of Greenland *via* Iceland and Faroe to Scotland does not exceed 500 fathoms. The depth of the sea in the English Channel is only about 20 fathoms, and the average depth of the North Sea or German Ocean is not over 40 fathoms or 240 feet. The depth between Britain and Greenland is small compared with the average depth of the Atlantic. The author closes with the conclusion, that one of the oscillations of level, such as have often occurred over the earth's surface, had the effect to "unite Britain and Northern Europe with Greenland and the Arctic regions;" "to give the polar ice-fields access to Europe;" "to divert the course of the Gulf Steam and free Northwestern Europe from its influence; and, in conjunction probably with some diminution in the influence of the sun, to produce a Glacial epoch."

8. *Geology of Spitzbergen.*—The following facts and views on the Geology of Spitzbergen are taken from articles by Prof. Nord-

enskiöld in the January and February numbers of the Geological Magazine, edited by H. Woodward, F.R.S.—The glacial scratches in the fiords opening into Bell Sound appear to indicate that the west coast of Spitzbergen extended at least to the series of islands and rocks by which the land is now environed; and that "during the Glacial period that coast was the west coast, not merely of an island, but of a considerable Arctic continent, which toward the south was connected with Scandinavia and toward the east with Continental Siberia." These words are italicized.

No strata containing Silurian fossils have yet been found, although it is probable that the Scandinavian Silurian formation is represented by dolomitic beds, slates, and quartzyte in Mt. Hecca Hook on Treurenberg Bay. The last-mentioned quartzyte in Lomme Bay is overlaid by slates, limestone, sandstone, and conglomerates, which have afforded remains of fishes and some other undetermined fossils and are probably of the age of Upper Devonian or Lowest Carboniferous.

The rocks of the Carboniferous age include a lower and an upper Subcarboniferous limestone, and the true Carboniferous formation.

The Lower Subcarboniferous beds (called "Ursa Stage" by Heer), are best developed on Bear Island, and include therein sandstone with some slate and coal; they occur also on Ice and Bell Sounds. The eighteen Bear Island species that have been determined are *Calamites radiatus* Brgn., *Cardiopteris frondosa* Gœpp., *C. polymorpha* Gœpp., *Palæopteris Rœmeriana* Gœpp., *Sphenopteris Schimperi* Gœpp., *Lepidodendron Veltheimianum* St., *L. commutatum* Sch., *L. Carnehgyianum* H., *L. Wijkianum* H., *Lepidophyllum Rœmeri* H., *Knorria imbricata* St., *Kn. acicularis* Gœpp., *Cyclostigma Kiltorkense* Haught., *C. minutum* Haught., *Halonia tuberculosa* Brgn.? *Stigmaria ficoides* St., *Cadiocarpum punctatum* Gœpp. and Berg., *C. ursinum* H.

The Upper Subcarboniferous formation consists, beginning below, of (1) dolomite; (2) red and white sandstone; (3) Cyathophyllum limestone, containing fossil *corals*, *Brachiopods*, *Crinoidal remains*, a *Euomphalus;* (4) Spirifer limestone and gypsum, affording numerous remains of *Spirifer* and some of *Productus;* (5) Productus limestone and flint. The formation has afforded 4 species of polyp corals, 2 of Crinoids, 7 of Bryozoans, 34 of Brachiopods, 11 of Lamellibranchs, 2 of Gasteropods, 2 of Crustaceans, and 1 of Spongia. They include some species that have been supposed to be exclusively Permian, as *Camaraphoria Humbletonensis* Howse, *Productus Cancrini* Vern., *Productus Leplayi* Vern., *P. horridus* Sow., *Strophalosia lamellosa* Gein. *P. horridus* is very abundant and occurs of great size (86 mm. by 67), nearly twice as large as is known from the Permian. The beds contain also the Silurian species *Rhynchonella pleurodon* Sow., but no *Orthis;* the Russian Subcarboniferous species *Spirifer incrassatus*, *Sp. bisulcatus* var. *Sarana*, *Terebratula fusiformis*, *Productus Humboldti*, *Chonetes variolaris;* and the Carbonifer-

ous species *Euomphalus cattilus*, *Monticulipora tumida*, *Chætetes radians*, *Cyathophyllum ibicinum*, *Syringoporæ*, etc.

The *Coal-Measures* have been distinguished on Spitzbergen only "in Robert's Valley, on the eastern side of the great bottom glacier in Recherche Bay," where the thickness is 1,000 to 2,000 feet. There is some black shale but no true coal. Species of *Sphenopteris*, *Cordaites* (*C. boracifolia* and *C. primordialis*), *Lepidodendron* are common, and some occur of *Stigmaria*, *Sphenophyllum*, *Asterophyllites*, but none of *Pecopteris* and *Neuropteris*. The same strata probably extend over Cape Ahlstrand to Van Keulen's Bay, and may occur at various other places.

The *Triassic formation* is met with in Ice Sound. The beds are principally black clay slate with some beds of limestone and coprolitic layers. The beds have afforded remains of *Ichthyosaurus polaris* Hulke (of the size of *I. Platiodon*), *I. Nordenskiöldii* Hulke, *Acrodus Spitzbergensis* Hulke, and other vertebrates yet undetermined, besides (according to Dr. Lindström) *Ceratites Malmgrenii* Lindstr., *Halobia Lommelii* Wissm., *H. Zitteli* Linds., species of *Posidonia*, *Monotis*, etc. Some of the coprolites contain 23 per cent of phosphoric acid.

9. *The Coal Eras of India, and a Permian or Triassic Glacial period.*—Mr. H. T. Blanford, in an able paper in the Quarterly Journal of the Geological Society of London for 1875, p. 519, discusses at length the age of the coal-bearing strata of India and the evidences of a Glacial era in underlying conglomerate beds.

(1). *Coal beds and Eras.*—He arrives at the conclusion, with regard to the coal-beds, that they range from the Lower Permian to the latest Jurassic.

The beds of the Dómúdá valley, the Rájmahál hills and numerous small basins west of the Gangetic delta consist, in ascending order, of (1), The Talchir group, 800 feet; (2), the Dámúdá series (including the Barákar group (2,000 feet), the Ironstone shales (1400) and the Rániganj group (5,000), 8,400 feet; (3), the Panchét group, 1,500 feet; and (4), Coarse sandstones and conglomerates, 500 feet. The flora of the Rániganj group, includes *Glossopteris Browniana*, *Phyllotheca Indica*, *Vertebraria Indica*, besides other species of these genera, and some also of *Pecopteris*, *Cyclopteris*, *Sphenophyllum*, *Calamites*, and *Schizoneura*. The overlying Panchét group contains species of *Sphenopteris*, *Tæniopteris*, *Neuropteris* (?), *Schizoneura*, *Preissleria*; also two *Labryinthodonts* (Huxley), a *Dicynodont*, a *Thecodont*, (*Ankistrodon Indicus* Huxley), an *Estheria*, etc.

In the Rájmahál hills, beds, supposed to be equivalents of the Rániganj group, are overlaid unconformably by the Rájmahál group, which contain, besides species of the last-mentioned genera, others of *Walchia*, *Voltzia* and an abundance of *Cycads*; all are specifically distinct from those in the older groups. Besides these species, the beds contain woods of *Dadoxylon*, *Palæoxylon*, *Taxoxylon*, and of *Angiosperms* of three or four varieties, but no ani-

mal remains. In the Nagpore country and Godavery valley, the Talchir and Damuda series are recognized, the latter with *Glossopteris Browniana*, etc., and, above the latter, the Panchét group, containing remains of *Ceratodus* and *Hyperodapedon*, both Triassic genera in Europe, and the former living still in Australia. Still higher, there are beds containing Cycads. In Cutch, there are Cycads in beds—probably equivalents of the last—that are either upper Jurassic or lowest Cretaceous.

Mr. Blanford speaks of the above correspondence—which has long been recognized—between the plants of the Damuda series and those of the coal measures in eastern Australia, 5,500 miles from the Indian localities, and in the Karoo formation in Natal,—South Africa. From the facts, he makes the beds in these distant regions alike in age, and Permian. The Beaufort beds, an upper member of the Karoo series, contain remains of *Dicynodon*, *Microlophis Stowii* Huxley, *Galesaurus* and *Cynochampsa*, along with *Glossopteris Browniana*, another Glossopteris, and a Phyllotheca near *P. Indica*; and they are made by the author equivalents of the Panchét group.

(2.) *Glacial era.*—At the base of the Talchir group, (as first announced in vol. i of the Q. J. G. Soc.) there is a conglomerate consisting of blocks of all sizes, up to *forty-two feet in circumference*, imbedded in a firm silt. The bowlders, as first shown by Dr. Oldham and Mr. Feddau, in 1872, are in part scratched and polished, part like the polish of a lapidary; and the underlying Vindhyan limestone is also scratched in long parallel lines. In the South African Karoo region, there is a similar bowlder bed beneath the coal measures, in which bowlders of granite, gneiss, etc., of all diameters up to *five* or *six feet* are imbedded in a grayish blue argillaceous base, which is in some places ripple-marked. These conglomerate beds have the great thickness of 800, and in some places, 1,200 feet. Below are beds containing *Lepidodendra*, etc., which have been referred to the Carboniferous. No similar bowlder bed has been observed in Australia. Mr. Blanford regards the bowlder beds as having originated under glacial conditions, and thinks it probable that those of India and South Africa point to one and the same Glacial era. Making the lower coal-beds Permian, the Glacial era is of the early Permian; contemporaneous with that indicated by the breccias of the British Lower Permian.

Mr. Tate, who has described, with Prof. T. Rupert Jones, the Karoo formation of South Africa, makes its age, as Mr. Blanford states, Triassic; and others have taken the same view of the coal beds (containing *Glossopteris*, etc.) of India and Australia. This view has to encounter the facts, stated by Rev. W. B. Clarke, that a coal miner's shaft sunk at Harper's Hill, New South Wales, passed through nearly horizontal beds containing *Spirifer*, *Fenestella*, *Conularia*, *Orthoceras*, etc., before reaching the conformable coal beds of the region full of *Glossopteris*, *Phyllotheca*, etc.; and also others, from Bowen River, Queensland, described by Mr. Dain-

tree, where the *Glossopteris* beds are *overlaid* by *Productus* and *Spirifer*-beds.

The paper is accompanied by a map showing the distribution of the plant beds in Eastern India, between the Ganges and the southwestern side of the Godavery River; and of others farther south, near Madras and Trichonopoly, and in the district of Cutch, where only the later beds have been observed.

10. *Graptolites.*—An article by Messrs. John Hopkinson and C. Lapworth, describing forty-five species of Graptolites from the Arenig and Llandeilo rocks of St. David's, illustrated by numerous figures on five plates, is contained in the Quarterly Journal of the Geological Society for November last. It is of special interest to the American geologist because of the many American forms which it reports from some of the British localities. In the lowest beds of the Arenig rocks, in Whitesand Bay, the species are all new; but on Ramsay Island, of nearly the same horizon, out of 16 species, 6 were first described by Hall from the Quebec group, viz: *Dendrograptus diffusus*, *D. divergens*, *D. flexuosus*, *Didymograptus extensus* and *D. pennatulus*, and *Trigonograptus ensiformis*. The beds also contain other species of the first two genera, and species also of *Phyllograptus*, *Ptilograptus*, *Callograptus* and *Dictyograptus* (*Dictyonema* Hall). The Middle Arenig beds of Whitesand Bay contain Hall's species, *Didymograptus patulus*, *Tetragraptus 4-brachiatus*, *Dendrograptus flexuosus*, *Callograptus elegans*, *C. Salteri*, and *Dictyograptus* (Dictyonema) *irregularis*; and the Upper Arenig of Ramsay Island, Hall's species, *Didymograptus bifidus*, *D. indentatus*, and *D. patulus*. No American species are among the eleven obtained from the Llandeilo formation: these eleven are of the genera *Didymograptus*, *Dicallograptus*, *Climacograptus*, *Diplograptus*, *Ptilograptus*, *Dendrograptus* and *Dictyograptus*.

11. *Region of eruptive rocks of the District of Schemnitz, Hungary.*—Mr. J. W. Judd, in a paper read before the Geological Society in April last, describes this Hungarian region of eruptive rocks. The rocks are andesites of the earlier upper Miocene age, rhyolytes of the later, and basalts of the Pliocene; also highly metamorphic rocks, including quartzytes, crystalline limestones, various schists, gneiss and aptyte, which are Triassic in age; and so-called syenyte, granite and greenstone. As held by Von Pettko, Richthofen, and others, the greenstones are Tertiary, they naming them greenstone-trachyte and propylyte; and, according to Judd, the granite and syenyte are only coarser forms of trachyte of the same age. The author also observes that there is complete proof that the mineral veins containing gold, silver and other metals, in Schemnitz, were formed "within the most recent geological periods, in some cases indeed, at a later date than the Pliocene."—*Nature*, No. 34.

12. *Volcanic phenomena of the Alps.*—Recent numbers of Woodward's "Geological Magazine" contain a valuable series of papers on volcanoes and volcanic phenomena, of British and European

regions, by Mr. Judd. The article in the number for May treats of the igneous ejections preceding the elevation of the Alps, which commenced in the Permian and continued through the Triassic. The best exhibitions of the erupted rocks are seen near the Lake of Lugano, on the borders of Switzerland and Italy, in the Southern Tyrol, and in the country about Raibl in Carinthia; and the author holds that they indicate that the same rocks occur beneath the Jurassic or other overlying beds throughout the Alpine region. The oldest (Permian)—the quartz-porphyry of Botzen, or a granite-like variety containing 66 to 76 p. c. of silica—covers an area of more than 1,000 square miles and constitutes mountain masses over 9,000 feet high. It is largely covered by Triassic beds of great thickness. Eruptions of the Triassic period occur in the Southern Tyrol; the rocks have the composition of melaphyre, diabase and doleryte, but are often granitic in texture, and are called monzonyte; and besides, there are tufas and volcanic ashes. Monzoni and Predazzo are noted localities, and especially because of the many minerals produced in the adjoining rocks by the erupted monzonite; among them, epidote, garnet, spinel, vesuvianite, gehlenite, mica, biotite, wollastonite, anorthite, labradorite, orthoclase, scapolite, monticellite, axinite, zircon, sphene, besides serpentine, thomsonite, chabazite, prehnite and others—a series closely related to that from the ejected masses on Somma.

13. *Reliquiæ Aquitanicæ.* Part xvii, Nov. 1875.—This number concludes the very valuable work of LARTET and CHRISTY on the "Archæology and Palæontology of Périgord, and the adjoining Provinces of Southern France," issued under the editorial supervision of Prof. T. Rupert Jones, and published by Williams & Norgate, London. The number of quarto plates in the whole work is eighty-three, and, besides these there are many wood-cut illustrations. This last number adds to the information on the human remains of Laugerie Basse, and concludes with notes on the *Caribou* (Reindeer) of Newfoundland, and comparisons of Reindeer remains from the caverns, giving a copy of a sketch of a Reindeer on a piece of Reindeer antler from a cave in the Canton of Schaffhausen; on the *Ovibos moschatus*, a northern species at the present time, whose remains have been met with not only in the Quaternary of Great Britain, but also in the "Diluvium" of the Oise near Chauny, and at Precy, and in that of the Saal in the Gorge d'Enfer (Dordogne). The last is at present the most southern locality known; and with the remains occur those of the Cave Bear, Cave Lion, Wolf, Aurochs and Reindeer. Next follow important "Supplemental notes," containing Addenda and Corrigenda for the work.

14. *On Dalmanites dentata*; by Dr. S. T. BARRETT.—Mr. J. M. Dolph of this place has recently found a nearly entire specimen of *Dalmanites dentata*, which enables me to add the following to my description of that species (p. 200 of the last volume of this Journal), and make some corrections. The thoracic segments are as described, except that all do not terminate laterally in slender

terete spines; the eight posterior segments do. Of the three anterior the first from the shield does not and the second does end obtusely, while the third has a spine about half the length of the fourth. These spines are directed outward and backward nearly at right angles to the rest of the segment, curving slightly upward near the end.

The entire specimen has an oblong-subelliptic general outline; length about equal to twice the width.

PORT JERVIS, N. Y., May.

15. *Note by Dr. Hayden, on the ore-bearing rocks of Colorado.*—In the annual report of the U. S. Geological and Geographical Survey of the Territories for 1874, on page 4, the statement is made that the "granites, schists, etc., are of probable Archæan Age, in which alone the precious metals and minerals of Colorado have been found." This statement was copied from the manuscript of Mr. Marvine, and was intended to apply only to his district, which embraced the Middle Park and the mountains about Georgetown and Central City. In the report of 1873 it was stated that ores of silver and gold occur in the Park Range, west of South Park, in limestones and quarzites of Silurian? Age, and in volcanic rocks, probably trachytic. In the Elk Mountains, galena and other silver ores occur in metamorphosed shales and quartzites of Cretaceous Age.

16. *Geology of Sumatra.*—The Geological Magazine for October and November, 1875, contains papers by R. D. M. Verbeek on the geology of Sumatra. An article on four fossil fishes, collected by Mr. Verbeek from the Lower Tertiary (or Upper Cretaceous) beds, has been published by Dr. Geinitz and Dr. V. d. Marck, in the Mitth. Königl. Min. Museum in Dresden. The article is illustrated by two plates.

17. *Report on the Geology of Wisconsin.*—This Report, prepared while the survey was under the charge of the late Dr. Lapham, is soon to be published, the Legislature of the State having appropriated $20,000 for the purpose.

18. *Geology for Students and General Readers.* Part I. *Physical Geology.* By A. H. GREEN, M.A., F.G.S. 522 pp. 12mo. London, 1876. (Daldy, Isbistin & Co.)--This volume gives a good review of Lithological and Dynamical Geology.

19. *Bulletin of the U. S. National Museum.* Department of the Interior. Published under the direction of the Smithsonian Institution. Nos. 1 and 2. 104 and 52 pp., 8vo.—No. 1. Contains three papers by E. D. COPE: (1) Check-list of N. A. Batrachia and Reptilia; (2) Check-list of the species of Batrachia and Reptilia of the Nearctic or N. American realm; (3) Geographical distribution of the Vertebrata of the Nearctic realm with especial reference to the Batrachia and Reptilia; (4) Bibliography. Mr. Cope's extensive knowledge of the species here considered and of their habits and distribution renders these chapters of great value to North American Science.

No. 2. Contributions to the Natural History of Kerguelen Is-

land made in connection with the American Transit-of-Venus Expedition, 1874–75; by J. H. Kidder, M. D., U. S. N. I. Ornithology, edited by Dr. Elliot Coues, U. S. A. The collection made by Dr. Kidder contains 11 Procellaridæ, 4 Spheniscidæ, 3 Laridæ, and 1 each of the families Phalacrocoracidæ, Anatidæ, and Chionidæ. The Introduction states that the highest peak of the island, Mount Ross, is 5,000 feet in altitude and always snow-covered. Near the sea, in December, the snow-line was found on Mt. Crozier at about 2,000 feet above the sea-level. Only 27 days out of four months were without snow or rain, and a still smaller number of nights; the mean temperature for the year is near the freezing-point, varying but little from this at any time; and the island is notorious for the violence of its gales. Consequently there are no trees or shrubs, and no plant taller than a Kerguelen cabbage; and the few phænogamous plants that survive are such only as can thrive exposed to these hardships. As a natural consequence, although the island is 90 miles by 50 in area, there are no land-birds or mammals living on the island, and but a single shore-bird, *Chionis minor.*

20. *Chemisch-genetische Beobachtungen über Dolomit,* (mit besonderer Berücksichtigung der Dolomit-Vorkomnisse Südost-Tirols), von Dr. C. Dœlter und Dr. R. Hœrnes.—This memoir contains a full review of the literature of the subject, with a discussion of the various theories which have been proposed to explain the existence of the great strata of dolomite. The results of an extended chemical examination of the dolomites of the Tyrol by Dr. Dœlter are given, embracing a considerable number of analyses. The authors reach the following conclusions, confirming in part the results of some earlier authors.

(1.) A large number of extensive strata of limestone, weakly dolomitic, have been deposited immediately through the instrumentality of organic life in the ocean.

(2.) Some minor occurrences of normal dolomite are due to subsequent metamorphosis, through the introduction of carbonate of magnesia.

(3.) The larger part of the dolomites, whether more or less rich in magnesia, have been formed from the lime secretions of sea-animals through the action of the magnesia salts contained in the sea-water (especially chloride of magnesium). Subsequent local differences have been brought about through circulating waters, dissolving out and concentrating the magnesia at different points.

E. S. D.

21. *On the Pittsburg Meteoric Iron;* by Dr. F. A. Genth.—A chemical examination of the Pittsburg meteorite yielded the following results: Its specific gravity, which Shepard gave as 7,380 was found to be 7,741, the average of three closely corresponding determinations by Dr. Kœnig, Dr. Headden, and myself. After polishing and etching with dilute nitric acid, it presents Widmannstättian figures, which are produced by inclosed schreibersite. In the section which has been made, it happens that most

of the exceedingly minute schreibersite crystals are cut across and are seen as small dots on a frosted surface; some appear as minute needles, arranged in parallel lines, like the trees in an orchard. A few elongated patches of a whiter iron-nickel alloy are also visible.

The analysis of a somewhat oxydized piece, gave the following composition:

Iron	92·809
Copper	0·034
Cobalt	0·395
Nickel	4·665
Manganese	0·141
Sulphur	0·037
Phosphorus	0·251
	98·332

0·251 per cent of phosphorus is equal to about 1·8 per cent of schreibersite.—*From the Report of the Geological Survey of Pennsylvania for* 1875.

III. Botany and Zoology.

1. *Tree-planting, Prizes for Arboriculture.*—Prof. C. S. Sargent, the Director of the Botanic Garden and Arnold Arboretum of Harvard University, published two or three months ago, *A Few Suggestions on Tree-planting*, in the Massachusetts Board of Agriculture's Report for 1875, and an edition was separately issued. The economical importance of re-foresting poor or agriculturally worthless lands in that State, and elsewhere, was strongly stated and judiciously enforced by plans and estimates, and the proper trees for planting on a large scale indicated. Another board, namely the Trustees of the Massachusetts Society for Promoting Agriculture, having some trust-funds at disposal, has now come forward, reprinted Prof. Sargent's pamphlet for gratuitous distribution, adding particular directions for the planting and management of seedling trees, and offering very handsome prizes for special plantations within the State of Massachusetts. This board offers, in the first place, for the best plantation of not less than five acres of larch, or on the cape, &c., of Scotch or Corsican pine, originally of not less than 2700 trees to the acre, on poor, worn-out or otherwise agriculturally worthless land, a prize of $1000. For the next best, a prize of $600; for the third best, $400. Next, for the best plantation of the same extent with American white ash, not less than 5000 trees to the acre, a prize of $600; for the next best, $400. Intending competitors must notify the Secretary of the Society, E. N. Perkins, Jamaica Plain, Boston, as early as Dec. 1, 1876, and plant in the spring of 1877. Special directions, not only for planting and caring for, but also for procuring trees for the purpose, are given in the pamphlet, and a citizen of Boston patriotically offers to look after the importation

of the seedling trees, which in such quantities and for next year's planting would have to be obtained mainly in Europe, at least the pines and larches. The ashes, probably, would have to be raised from seed; and the time, if need be, would doubtless be extended. The prizes to be awarded in the summer of 1877. Mr. Sargent's estimates promise a handsome return for the capital and labor invested in judicious tree-planting for economical purposes; these timely prizes may stimulate enterprise; and the sense of contributing to the adornment as well as to the material resources of the country should also be a motive and a reward. A. G.

2. *Heteromorphism in Epigæa.*—The May-flower, being more largely gathered and brought under our notice than any other wild blossom—at least in the Atlantic States—should be well known in all the details of structure. But it hardly is so. The structure of its stigma was first well described in the 5th edition of my Manual of the Botany of the Northern United States, and the likeness to *Pyrola* suggested. I suppose that this likeness is really one of relationship, but not of a near degree, as most other points of similarity are wanting. From the difference in the stigmas of different flowers, I was disposed to think that the five lobes lengthened and protruded with age, in the manner of *Pyrola;* but this does not prove to be the case. In all cases, however, the apex of the style is as it were hollowed out or extended into a ring, with a 5-crenate border, to the inner face of which the five stigmas are adnate, each before one of the small teeth or lobes, and extending sometimes slightly beyond it, but remaining short and erect, sometimes much beyond and radiately expanded.

In Michaux's Flora is the note "Flores omnes in nonnullis individuis abortivi," and botanists are generally aware that fruit is seldom met with. The flowers have been said to be unisexual (diœcious); but all appear to have well formed ovary and ovules, although some individuals were known to want the stamens. Professor Goodale, knowing a station in Maine in which *Epigæa* year after year sets fruit, kindly procured from thence a large number of fresh specimens; and these I have now examined in regard to stamens and pistil. They show the following heteromorphous condition of things.

(1.) About ten per cent of the specimens have a style considerably longer than the stamens, raising the stigmas a little out of the throat of the corolla, in which the anthers are included: the stigmas are cylindraceous, radiate like the spokes of a wheel, half a line in length, therefore strongly projecting, moist and glutinous, and evidently in good condition for fertilization. The anthers in these flowers are slender, commonly withering without dehiscence, and containing few yet perhaps well-formed pollen-grains. The fruiting specimens gathered at the same station in former years all evidently belong to this form, as the persistent style and long stigmas show. One or two specimens of this form manifest a disposition to convert their anthers into petals; but this is occasionally seen in other forms.

(2.) A smaller number of specimens show the stigmas of the preceding on a shorter style, sometimes so short as to place the radiating stigmas as low as the middle of the tube of the corolla, sometimes bringing it nearly up to the throat. In one instance a short-styled flower was detected in a cluster of flowers otherwise of the character of No. 1. These short-styled blossoms, instead of having more conspicuous or higher anthers than in the long-styled, bear them either at the same proportional height and in the same condition, or bear mere rudiments of anthers, or not rarely none at all, and even the filaments are smaller, abortive, or occasionally altogether wanting. This sometimes happens in No. 1 also.

(3.) The larger number of flowers, perhaps three-fourths of the specimens under examination, have the long style of No. 1, an ovary equally well-formed and ovuliferous, but either rather smaller or not going on to grow; but the stigmas are short, only slightly projecting beyond the lobes of the cup to which they adhere, in all stages erect, and comparatively smooth and dry. Their tips, however, appear somewhat papillose under a strong lens, and grains of pollen placed thereon incline slightly to adhere, yet not so much as upon the surface of the style far below, which gets well covered with pollen from the contiguous anthers. The difference between these stigmas and those of the foregoing forms is striking and constant, no gradations between them having been detected. The anthers abound with pollen, and are dehiscent at or a little before the opening of the corolla.

(4.) A considerable number of such flowers have a shorter style, so that the stigma stands as low as the base of the five longer anthers, in one or two even lower than all the anthers, otherwise all is as in No. 3, of which this seems to be a mere variation. And here also, although not very definitely, there is a tendency to having lower instead of higher anthers in connection with the short style.

The flowers of *Epigæa* may therefore be classified into two kinds, each with two modifications; the two main kinds characterized by the nature and perfection of the stigma, along with more or less abortion of the stamens; their modifications, by the length of the style. The first is leading to dioicism, the second points to dimorphism. I am not aware that either unisexual or dimorphous flowers are otherwise known in the *Ericaceæ*. Dimorphism (as exemplified in Primroses, *Houstonia*, and *Mitchella*) may be regarded as the more perfect arrangement on the score of economy, as it secures cross-fertilization along with fertility of all the flowers. It would seem as if this had been attempted in *Epigæa*, but that the stamens did not respond with the requisite correlation to the long and short styles; and the same may be said of certain flowers in one or two other families. Of dichogamy, the other equally economical method, I find no indication in *Epigæa* blossoms. But they appear to be now falling back upon the remaining, less economical mode of securing the end, namely, by unisexual blossoms.

It would be interesting to know whether the small-stigma

forms of *Epigœa* are ever fruitful, or fully so. It might not be difficult to ascertain the kind of flower in any case which has matured fruit; for the style and stigmas persist until the capsule is well formed in the fruit thus far known.

The æstivation of the corolla is that of the tribe, imbricated, but with a strong tendency to convolute; more commonly there is only one exterior and one interior lobe. A. G.

3. *Essay on the Immigration of the Norwegian Flora during alternating Rainy and Dry Periods*, (with a colored map of Norway); by AXEL BLYTT. Christiania. pp. 87, 8vo. 1876.—This is the substance of two lectures delivered by Dr. Blytt at meetings of the Christiana Natural History Society, in January and in October, 1875. Dr. Blytt's father was the most accomplished botanist of Norway, and the son takes naturally and lovingly to the same pursuits. Following the example set by Dr. Thorel and other Scandinavian naturalists, and which is to us pleasant and convenient, Dr. Blytt publishes this essay in the English language, which he writes correctly and with apparent ease.

There are, so to say, two floras in Norway; one, which may be termed the insular, belongs to the coast or western part of the country, to which the Gulf-stream has given an insular character of climate; the other, the continental or boreal. There are, besides, the generally diffused species, which are indifferent to the variations of climate. The rare continental species prefer a dry and loose substratum; the insular, a solid or moist soil; and there are remarkable leaps in the extension of both the continental and insular species. To explain these leaps is to bring in the question of the migration of plants. "Do plants migrate all at once across large tracts, or do they extend themselves little by little and by short distances at a time?" Although drifting ice, bringing seeds and plants lodged in earth, is a known means of transport, yet "everything indicates that conveyance to small distances is the rule." The case of the Norwegian flora "becomes easily intelligible if we assume that our climate since the ice-period has undergone secular alterations; that it has been at certain times more insular, and at others more continental; when a dry period is succeeded by a moist period the continental species must become rarer; when a moist period is followed by a dry time the plants which love moisture will be scarcer. Thus the great leaps in the distribution of species seem to point to a more continuous extension in ancient times." The study of peat-bogs resting on the site of extinct forests, and these of different ages and character, furnishes evidence of these perturbations of climate, extending through long and remote periods. "During such alternating periods," wholly prehistoric, "the country seems therefore to have received its present vegetation. We see it first covered with inland ice, which projected out into the sea and dispersed Scandinavian migratory blocks over the plains of Central Europe. When the ice, during a drier period, retired from the shore, a flora immigrated resembling that which now adorns the

wastes of Spitzbergen, North Greenland, and Melville Island,—small, hardy, and tuft-forming plants, which often display an unexpected splendor of flowers with the purest and deepest colors. Then came the gray osiers, juniper and birch, cherry-ash and rowan, with a host of new immigrants. The moisture increased, peat began to grow, and the arctic flora to recede. But the climate became warmer; the ice melted more and more; elm and hazel, lime, ash and maple, and other tender foliferous trees came, with a number of species that grow in their company. At that time the climate was dry. But when the land rose further a new revolution came about. A great rainy period buried the foliferous forests in peat; then came fox-glove (*Digitalis*), holly (*Ilex*), and the other species which we now find, especially in the rainy regions of the west coast. A new dry period followed, and pine forest grew on the bogs. Again came a rainy period. The pine forests were buried in peat. And during these last changes in our climate there came, probably, that part of our flora which is peculiar to our lowest southernmost regions."

"Our flora has acquired a uniform stamp, because some few species, which were insensible to the changes of climate, have little by little conquered a place which there is now no cause for giving up. But, here and there, on the friable slates in the mountain districts, on the moist mountain slopes and in the forest valleys, as also on wild rubble-slopes, under steep walls of rock, on the heather-tracts of the west coast, on the slate rocks in the Christiania fiord, on the cliffs of the coast in the province of Christianssand, on the gravel and sand of the edge of the shores, we find remains from these days gone by, remains which relate how our country received, little by little, the vegetation that now clothes our mountains and valleys."

With few and doubtful exceptions all the plants of Norway are also found beyond the borders of the country; there are peculiar forms, but none distinct enough from its congeners to be unequivocally recognized as a distinct species. Such forms, as Prof. Blytt remarks, are what would be expected under the vicissitudes which he refers to. A species with an unbroken and continuous hold and full occupation of a region has little chance for fixing variations. But forms reduced to isolation by stress of circumstances, having no opportunity to cross with their brethren, will preserve and have the best opportunity to develope their individual peculiarities, fix them into a race or subspecies, and when a turn of the climate favors them may multiply and occupy the district with a race markedly different from the common type of the species elsewhere. A. G.

4. *Genera Plantarum*, . . . *auctoribus* G. Bentham et J. D. Hooker. Vol. secundum, sistens Dicotyledonum Gamopetalarum Ordines XLV, Caprifoliaceas—Plantagineas. Londoni, 1873–1876.—This is the title page, somewhat shortened, of the second volume of this noble work, of which the first part, 533 pages, was issued in the spring of 1873, and the second—bringing the volume

up to 1279 pages, and the subject to the end of the *Gamopetalæ*, followed by some corrections and a good index—is now happily before us. Our scattered botanists will be glad to know this; also that the third and final volume, according to present prospects, will not be long delayed. Considering the extent and formidable character of this undertaking, and the large amount of other work which both authors have upon their hands, the rate of progress thus far is remarkable. The work has the names of two well-known London publishers upon the title page, Reeve & Co., and Williams and Norgate, and can be had through the ordinary channels of the trade. If any of our botanists who desire to order it have any difficulty in the way of procuring it through the booksellers, they are at liberty to communicate with the writer of this announcement. A. G.

5. *Botany of California.* Vol. I. *Polypetalæ*, by W. H. BREWER and SERENO WATSON. *Gamopetalæ*, by ASA GRAY. 1876. —This long-expected volume has at length made its appearance. It fills 628 pages, besides the 25 pages of prefatory matter, and is uniform with the publications of the Geological Survey of the State of California, of which it was intended to form a part, and may still do so, if the State soon takes it up. There is no necessity of appending to this announcement a history of this work. Suffice it to say that the present volume—the larger part of the projected work—is now brought out and placed within the reach of botanists and those interested in the results of botanical investigations, by the indomitable perseverance and energy of the State Geologist, Prof. Whitney, and by the considerate liberality of the following gentlemen, citizens of California, who furnished the means for carrying it on after the State abandoned it, viz: *Leland Stanford, D. O. Mills, Lloyd Tevis, J. C. Flood, Charles McLaughlin, R. B. Woodward, William Norris, John O. Earl, Henry Pierce, Oliver Eldredge, S. Clinton Hastings.* The scientific gentlemen engaged have done their part, and those who have done the State's duty in the premises are understood to be ready to supply the necessary means for carrying the second and concluding volume through the press. When this is done it may be said that no other State in the Union has such a well-ordered and complete Flora.

The Introduction, by Prof. Whitney, giving some account of the undertaking, fills three pages. A note supplies some special explanation of the plan of the work; the remainder of the Preface is occupied by two keys to the Natural Orders herein comprised; first, an analytical artificial key; second, a synoptical key, giving the orders in their sequence, or nearly so, and with reference to exceptional cases and anomalies. The two may supplement each other, and greatly assist the ordinary student or amateur botanist, who cannot be expected to have the characters of the orders well in hand, nor to recognize aberrant members at the first glance. Such keys are very useful, almost indispensable; but it is impossible to make them perfect so as to provide for every case. They

should be used as helps, not as an absolute reliance or as a mechanical substitute for brains.

The *Polypetalæ* occupy 276 pages; the *Gamopetalæ*, 346. Without reference to the scientific merits of this work—of which others will judge—we are free to pronounce its plan and its typography as unsurpassedly excellent. A. G.

6. *Quarterly Bulletin of the Nuttall Ornithological Club, Cambridge, Mass.*, vol. I, No. 1, April, 1876. 28 pp. 8vo, with one beautifully colored plate.—The annual subscription for this valuable publication is only one dollar, or 30 cents per number. It is to be issued quarterly in numbers of 16 pages.

IV. Astronomy.

1. *Astronomical Tables, comprising logarithms from* 3 *to* 100 *places;* by Henry M. Parkhurst. New York, 1876.—We have received a copy of these tables, now issued by the author though his plan for the whole work is still but partially worked out. The first part of the book of 224 pages contains about 70 tables. Elaborate tables are given to aid in computing logarithms to a large number of decimals, to 8, 10, 15, 20, 30, 60, and even 100 places, by a method which the author claims as new. Ordinary four-figure tables of logarithms, addition and subtraction logarithms, log. sines, tangents, &c. Numerical tables, as primes, least divisors, reciprocals, multiples, squares, &c., follow, which with the logarithms make about three-fourths of the tables. The remainder consists of about 40 astronomical tables of various kinds. In Parts 2d and 3d are explanations of the use and the theory of the tables. They are full of interesting and valuable suggestions and information from the author's experience as an amateur observer. They also contain large numbers of formulas for astronomical computation. To many the use of phonetic print will be repulsive, but we wish success to any effort to simplify the spelling of English words. The author's occupation as a stenographer has led him to condense the tables and use abbreviations at the expense, in some cases, of clearness. He has certainly succeeded in putting into a moderate size a large variety of useful matter.

V. Miscellaneous Scientific Intelligence.

1. *Probability of error in writing a series of numbers.* Letter to the editors, dated St. Louis, May 10, 1876.—Not long since while writing logarithms that were being read to me, I observed that the probability of error in writing the numbers appeared to be much less at the extremities of the number, than in the middle. This has been investigated quite at length with numbers of from five to ten digits. It is found that the probability of error is in all cases expressed by the terms of the expanded binomial

$$(a+b)^n$$

where n is a function of the number of digits. Thus far a and b

have always been unequal, with all the persons yet experimented upon. The probability of error is greatest just after the middle of the number.

This has led to an interesting investigation on the power of memory. Allowing definite intervals (t) of time to elapse between the giving and the writing of the number, and it is evident that the number of errors will increase with the value of t.

In order to aid the experimenter in abstaining from mentally repeating the number which he is to write, he is allowed to determine the value of (t) by counting the beats of a seconds pendulum. The investigation is yet in progress, but enough has been done to develop the fact that the relation between the number of figures (per 100) written correctly, and the values t, is a logarithmic one. It is the same as the function expressing the decrease in the amplitude of the beats of a pendulum, in time, as due to a resisting medium. F. E. NIPHER.

2. *Record of Science and Industry for* 1875; edited by SPENCER F. BAIRD. 646 pp. 8vo. New York, 1876. (Harper & Brothers.)—Professor Baird's scientific annual for 1875 has recently been issued. It is a work not only for men of science, but also for all who would inform themselves as to the new facts and discoveries in science and the practical arts, and learn something of the world's progress in knowledge.

3. *Transactions of the Connecticut Academy*, vol. III, part I. —This volume contains: I. A report on the dredging in the region of St. George's Banks in 1872, by S. I. Smith and O. Harger, with 8 plates; II. Descriptions of new Hydroids by S. F. Clark, with 2 plates; III. On the Chondrodite of Brewster, N. Y., by E. S. Dana, with 3 plates—the paper which was condensed for volume ix of this Journal; IV. On the Transcendental Curves $\sin y \sin my = a \sin x \sin nx + b$, by H. A. Newton and A. W. Phillips, with 44 plates, containing photo-lithographic transfers of 148 different examples of the curves; V. On the equilibrium of Heterogeneous Substances, First Part, by J. Willard Gibbs, a profound paper, occupying 150 pages, putting new methods of analysis in the hands of mathematicians and physicists.

Notes of the following works are unavoidably deferred:

Bulletin of the U. S. Geological Survey of the Territories. Vol. II, No. 3.

Geographical Distribution of Plants. Part II. Plants in their wild state; by Charles Pickering, M.D., author of The Races of Men. 524 pp. 4to. 1876.

Report on the Geology of the Eastern portion of the Uinta Mountain, and a region of Country adjacent thereto; by J. W. Powell. 218 pp. 4to, with an atlas. Washington. Department of the Interior. 1876.

Geological and Natural History Survey of Minnesota. Fourth Annual Report, for 1875; by N. H. Winchell, State Geologist. 80 pp. 8vo. St. Paul, 1876.

Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Region. 630 pp. 4to, with 45 plates. 1876. Vol. ix of the Quarto Series of the U. S. Geol. Survey of the Territories in charge of Dr. F. V. Hayden. Department of the Interior.

OBITUARY.

ANGELIN, the eminent Swedish Paleontologist, died at Stockholm on the 13th of February, aged seventy years.

E. BILLINGS, the able Paleontologist of the Canadian Geological Survey, has recently died.

APPENDIX.

ART. IX.—*On a new Crinoid from the Cretaceous formation of the West;* by GEORGE BIRD GRINNELL. With Plate IV.

AMONG the many interesting fossils recently received from the West by the Yale College Museum, is a new Crinoid from the Cretaceous of the Uinta Mountains and of Kansas. No crinoids from the American Cretaceous have hitherto been described, and for the discovery of this species we are indebted to Prof. O. C. Marsh, who has done so much to bring to light the geological treasures of the West.

The Crinoid in question belongs to the group *Astylidæ*, or free Crinoids, and, as suggested by Prof. Marsh in his earliest paper on the Geology of the Uinta Mountains,* is allied to the genus *Marsupites* of Miller. From that genus, however, it differs widely in the number and arrangement of its plates, in having apparently ten arms, and in other characters; and it is possible that an examination of additional material may show it to be the type of an entirely new group. This point, however, cannot at present be determined.

Uintacrinus socialis, gen. et sp. nov.

The body as seen is somewhat discoidal in form, owing to pressure, but in life was evidently subglobose. The basal and subradial plates are imperfectly known. In the most perfect specimen, (figure 1,) three radial plates are found, irregularly pentagonal, hexagonal, or heptagonal in form, and varying considerably in size. Of these, the third or superior seems to be always the largest and most regular in outline. It is heptagonal, and two of its longest sides slope downward from the superior angle. The second radial is about equal in size to the first. All are wider than high. The third radial bears on each of its superior sloping sides in immediate succession five secondary radials, irregularly pentagonal or hexagonal in shape, and all wider than high. The fifth of these approaches in shape the proximal armpiece, to which it gives immediate support.

The arm pieces are thin, and horizontally compressed from without inward, their shape being sub-elliptical. The arms give support to delicate pinnulæ, or tentacles, for a portion of their

* This Journal, vol. i, p. 191, March, 1871.

length, though at what point these first appear is as yet uncertain. The more distant arm pieces show, when the articular surfaces can be examined, a distinct radiate structure, and there are traces, in some of the pieces which are exposed, of a canal, which in life may have given passage to the "axial cord" (nerve) of Dr. Carpenter. There is also to be seen on the inner side of several of the more distant arm pieces a deep depression, the radial furrow, which gives to the plates a subcrescentoid shape. These characters cannot be well made out, as all the pieces which show them are badly weathered. The arm pieces diminish very gradually in size, and the arms are long. On one of the slabs they have been traced continuously for a distance of eight inches with but little change in size, and it seems probable that in life the spread of the outstretched arms may have been two feet or more.

The interradial arms are irregular in shape, somewhat contracted near the middle, becoming wider above and below. They consist of about sixteen large irregular plates varying widely in size, and of from sixteen to twenty smaller ones, placed high up between the arms, and in part concealed by them. The former range from pentagonal to octagonal in shape, and although the specimens are not sufficiently perfect to enable the arrangement to be determined with certainty, it seems to be as follows: commencing below, opposite the first radial is a single plate; next above, in line with the second radial are two; and then three opposite the third. Succeeding these, and lying between the first of the secondary radials, is a single wide octagonal plate, and above this eight others, somewhat irregular, extending up in pairs to between the fifth secondary radials (figure 1). Immediately above these eight follow the smaller plates, four or six in a horizontal series, diminishing rapidly in size, and soon disappearing beneath the arms. A very small quadrangular plate is inserted between the first and second radials and the interradial plates which are opposite these. It is not certain, however, that this arrangement is altogether constant. In fact the other side of the specimen from which this is taken, though too imperfect for use, suggests a larger interradial arm, and hence, a probable difference in the number of the plates.

The interaxillary areas consist of about ten large plates and from sixteen to twenty smaller ones, the latter arranged much as in the interradial arm. Of the larger ones, several of the lowermost are much weathered, and their shape and arrangement cannot be positively ascertained from the specimens at hand. The inferior plate is the largest. It is higher than wide, octagonal, and somewhat shield-shaped, apparently supporting, on its superior sloping sides two high and rather narrow pieces, which in turn, give support to two small subtriangular plates.

Above these are four others in pairs, and these are followed by the smaller ones in fours, becoming rapidly less in size, as in the interradial arm.

The specimens are found in a soft light-colored limestone, and a considerable mass of the rock is often made up of their remains, as shown in the accompanying plate, figure 2, indicating that the individuals of this species lived together in large numbers. To this fact the specific name refers. It is needless to remark at length on the great interest which attaches to this species, the first crinoid known from the Cretaceous of the new world. The fact that it lacks a stem, thus resembling the genus *Marsupites* from the English chalk, suggests the advance made by some of the Crinoids that survived until the Cretaceous, over the older forms that lived in Paleozoic time.

The first specimen of the species here described was discovered by Prof. Marsh in the Cretaceous of the Uinta mountains during the autumn of 1870. It was found associated with the scales of a *Beryx*, and *Ostrea congesta* Con., typical Cretaceous forms. The species is apparently rare in this locality, as a diligent search by the writer and other members of the expedition failed to bring to light any more specimens. Others have since been received from the Cretaceous of Kansas, where they were associated with the Odontornithes, Pterodactyls and Mosasauroid reptiles of that formation.

The writer is under many obligations to Prof. Marsh for the opportunity of examining these specimens, and for most valuable suggestions in regard to the literature of the subject.

YALE COLLEGE, New Haven, June, 1876.

Explanation of Plate.

Figure 1. *Uintacrinus socialis.* Side view of a specimen showing radials and interradial arm. Natural size.

Figure 2. *Uintacrinus socialis.* Side view of a weathered specimen showing radials, interaxillary area, arms and pinnulæ.

a and *b*. Two of the more distant arm pieces magnified, showing the radial furrow, and indistinctly, the grooves radiating from the center.

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[THIRD SERIES.]

ART. X.—*The Colorado Plateau Province as a Field for Geological Study;* by G. K. GILBERT.

[Continued from page 24.]

[It has happened that the division of this paper into parts has interrupted the sense, and I shall therefore have to ask the reader who would understand this page to refer again to the figures on page 23 of this volume.

BETWEEN the Hurricane and Toroweap faults is contained the U′-in-ka-ret block. It is tilted slightly toward the east and is fifteen miles broad. Upon it stands a group of volcanic mountains, the lavas of which have risen through fissures in the block. Between the Toroweap and West Kaibab displacements is the Kan-ab′ block, thirty miles broad. It appears level in the east-west section, but has, in common with all the other blocks of the sketch, a gentle dip to the north. Its cap of Carboniferous limestone is divided in the foreground by the cañon of Kanab creek, and fifty miles away it passes beneath Triassic sandstones. The Kaibab block stands highest of all. The strata, which for fifteen miles run level on its summit, are flexed downward at both margins, on one side to the Kanab block, and on the other to the Marble Cañon block. Its upper surface is the Kaibab Plateau. The Marble Cañon block is thirty miles broad. On the line of the section its highest bed is of Carboniferous age, but a few miles farther north it retains a heavy bed of Trias, which rises 2000 feet higher and constitutes the Paria Plateau.

The features of the region pictured to which I wish especially to call attention, are:

First, that there are no anticlinals and no synclinals, but only monoclinals and faults;

Second, that the throws of the displacements are not all on the same side;

Third, that the visible portion of the earth's crust is divided into great blocks, which have changed their relative and absolute altitudes by thousands of feet, without losing their individuality.

The structure of this region is an unusually pure example of a type that, with various modifications, prevails throughout the Plateau region, and Major Powell has taken a name from the locality and called it the *Kaibab structure*. We cannot study the embryology of mountains by observing the progress of an individual, but it is possible, by the comparison of many individuals in various stages of development, to learn something of the manner of mountain growth, and, studying the subject in this way, the conclusion has been reached that many mountain ranges are built upon the plan of the Kaibab Plateau. The essential feature of the plan is the upward movement *en masse* of a great body of rock between two planes of displacement. A *plateau* is thus produced, from which mountain forms are carved by the ordinary processes of erosion. Evidences of such a plan have been found in nearly all the mountains of the upper basin of the Sevier River, in some of the ranges of the Great Basin, by Major Powell in the Uintah range, and by Mr. Marvine in the Front and Medicine Bow ranges of Colorado. Few of these cases are so simple as that of the Kaibab Plateau. In some the block has been lifted more on one side than on the other, so as to acquire a dip; in other cases there are a number of blocks of different elevation in the same range; in yet other, the blocks are somewhat curved.

I shall not attempt to enumerate the variations of the type, which arise in these several ways. The purpose of the illustration is accomplished, if I have shown that the exceptional exhibition, in the Plateaus, of displacements which are simple and easy of comprehension, has already led to the recognition of a new class of mountain structures, or at least of a class so little known heretofore that it has not found place in the manuals of geology.

When the displacements of the region have all been worked out, it will be possible to construct a model which shall exhibit the structure of at least one hundred and fifty thousand square miles of the earth's crust, showing the form and position of each of the blocks which compose it; and I conceive that such a model, or an equivalent presentation of the same material by some other method, will not be inferior in value to any single contribution that has been made to our knowledge of the results of orographic movements.

Mountain building by eruption.—The studies, which the Plateaus afford in the phenomena of eruption, are scarcely less interesting and important than those of uplift and downthrow; but they have received less attention up to the present time. It happens that a number of extinct eruptive mountains stand near the cañons of the Colorado River. The country about them has suffered and is suffering rapid denudation, and not only are their bases nearly free from detritus, but their flanks are so deeply scored, and their summits are so degraded, that their internal structure is exhibited. Those that are best known have been found to be composed chiefly of sedimentary strata, protected from denudation by the superior durability of the eruptive rocks with which they are associated.

In the U′-in-ka-ret mountains Major Powell found a mass of undisturbed strata, which had been preserved from erosion by a mantle of lava, while the surrounding country was degraded more than a thousand feet. The eruptions were extended through a long period of time, and the successive outflows mantled the flanks of the surviving strata almost as thoroughly as they did the summit, so as to give the appearance, at first glance, of a range made up entirely of volcanic matter.

In the Henry Mountains the strata are not undisturbed, but have been lifted into a number of bubble-shaped domes, one for each individual mountain of the group. Each dome has been fractured at top, and divided by fissures radiating from the center toward the sides, and all the fissures have been filled by molten rock. Moreover the strata have in many places cleaved apart, and lava sheets have been interleaved with them.

Doubtless the intrusion of these dikes and sheets was accompanied by extrusion, but none of the extruded masses appear to have survived the subsequent erosion. The mountains as they stand are simply domes of curved strata, each traversed by a plexus of crystalline dikes.

Similar in structure to the Henry Mountains are Navajo Mountain, Sierra la Sal, and Sierra Abajo. Mount San Francisco, and perhaps Mount Taylor, are related to the Uinkarets. This enumeration includes but a small portion of the volcanic mountains of the district, and to the two types of structure mentioned, several others might be added. But the mountains of the Uinkaret and Henry types are most favorably situated for study, and at the same time diverge most widely in character from those with which geologists are already familiar.

Stratigraphy.—In the stratigraphy of the Plateaus attention has thus far been confined to questions that are chiefly of local importance, but a thorough study of the phenomena which are accessible can hardly fail to throw light on the

principles of sedimentation. In the region of cañons a single bed can be followed, upon one continuous outcrop, for hundreds of miles, and every modification that it undergoes can be traced step by step. Moreover, by reason of the ramifications of cañons, it is frequently possible to trace a bed toward all points of the compass, so as to learn its changes, not merely along a simple line, but throughout an extended area. With such exposures, unconformity cannot escape detection, and the history of a system of sediments can be made out with a completeness that surely cannot be excelled elsewhere.

Part II. Erosion.

It remains to indicate the scope of the material bearing upon the subject of erosion, and with that intent I will discuss certain problems which the region has propounded. The first may be called

The Problem of the Cañons.

The deep gorges which so facilitate the examination of the strata and of their displacements, are themselves of interest as monuments of erosion. To account for their existence and unravel their history is to review the laws of erosion with great wealth of illustration. Results so extreme can have been produced only under conditions equally extreme; and natural laws are often best tested and exemplified by the consideration of their operation under exceptional circumstances. Already the problem of the cañons has been attacked, and I cannot better demonstrate its radical value than by presenting the present aspect of the case. For this purpose it is necessary to give a summary statement of the processes of erosion and of the conditions which determine its rate. The matter is so complex that this cannot be done briefly without the omission of the less important factors, and in undertaking it I shall take the liberty of either disregarding or slighting all considerations which have not an important bearing on the problem in question.

In order to analyse sub-aerial erosion, we must consider it (A) as consisting of parts, and (B) as modified by conditions.

A. All indurated rocks and most earths are bound together by a force of cohesion, which must be overcome before they can be divided and removed. The natural processes by which the division and removal are accomplished make up erosion. They are called disintegration and transportation.

Transportation is chiefly peformed by running water.

Disintegration is naturally divided into two parts. So much of it as is accomplished by running water is called corrasion, and that which is not, is called weathering.

Stated in their natural order, the three general divisions of the process of erosion, are (1) *weathering*, (2) *transportation*, and (3) *corrasion*. The rocks of the general surface of the land are disintegrated by *weathering*. The material thus loosened is *transported* by streams to the ocean or other receptacle. In transit it helps to *corrade* from the channels of the streams other material, which joins with it to be transported to the same goal.

(1.) In weathering the chief agents of disintegration are solution, change of temperature, the beating of rain, and vegetation.

The great solvent of rocks is water, but it receives aid from some other substances, of which it becomes the vehicle. These substances are chiefly products of the formation and decomposition of vegetable tissues. Some rocks are disintegrated by their complete solution, but the great majority are divided into grains by the solution of a portion; and fragmental rocks usually lose by solution the cement merely, and are thus reduced to their original, incoherent condition.

The most rigid rocks are cracked by sudden changes of temperature; and the crevices thus begun, are opened by the freezing of the water within them. The coherence of the more porous rocks is impaired and often destroyed by the same expansive force of freezing water.

The beating of the rain overcomes the feeble coherence of earths, and assists solution and frost by detaching the particles which they have partially loosened.

Plants often pry apart rocks by the growth of their roots, but their chief aid to erosion is by increasing the solvent power of percolating water.

(2.) A portion of the water of rains flows over the surface and is quickly gathered into streams. A second portion is absorbed by the earth or rock on which it falls, and after a slow underground circulation reissues in springs. Both transport the products of weathering, the latter carrying dissolved minerals, and the former chiefly undissolved.

Transportation is also performed by currents of air, and by the direct action of gravity; but in the present discussion it will not be necessary to consider these accessory agents.

(3.) In corrasion the agents of disintegration are solution and mechanical wear. Wherever the two are combined, the superior efficiency of the latter is evident; and in all fields of rapid corrasion the part played by solution is so small that it may be disregarded.

The mechanical wear of streams is performed by the aid of hard mineral fragments which are carried along by the current.

The effective force is that of the current; the tools are mud, sand, and bowlders. The most important of them is sand; it is chiefly by the impact and friction of grains of sand that the rocky beds of streams are disintegrated.

Streams of clear water corrade their beds by solution. Muddy streams act partly by solution, but chiefly by attrition.

Streams transport the combined products of corrasion and weathering. A part of the debris is carried in solution, and a part mechanically. The finest of the undissolved detritus is held in suspension; the coarsest is rolled along the bottom; and there is a gradation between the two modes. There is a constant comminution of all the material as it moves, and the work of transportation is thereby accelerated. Bowlders and pebbles, while they wear the stream-bed by pounding and rubbing, are worn still more rapidly themselves. Sand grains are worn and broken by the continued jostling, and their fragments join the suspended mud. Finally the detritus is all more or less dissolved by the water, the finest the most rapidly.

In brief, (1) weathering is performed by solution; by change of temperature, including frost; by rain beating; and by vegetation.

(2) Transportation is performed chiefly by running water.

(3) Corrasion is performed by solution, and by mechanical wear.

Corrasion is distinguished from weathering chiefly by including mechanical wear among its agencies, and the importance of the distinction will be apparent when we come to consider how greatly and peculiarly this agency is affected by modifying conditions.

In the region of cañons, the progress of corrasion has outstripped that of weathering, and to discover what conditions have determined this result, is to solve the problem of the cañons.

B. The chief conditions which affect the rapidity of erosion are (1) declivity, (2) character of rock, and (3) climate.

(1.) In general, *erosion is most rapid where the slope is steepest;* but weathering, transportation and corrasion are affected in different ways and in different degrees.

With increase of slope goes increase in the velocity of running water, and with that goes increase in its power to transport undissolved detritus.

The ability of a stream to corrade by solution is not notably enhanced by great velocity; but its ability to corrade by mechanical wear keeps pace with its ability to transport, or may even increase more rapidly. For not only does the bot-

tom receive more blows in proportion as the quantity of transient detritus increases, but the blows acquire greater force from the accelerated current, and from the greater size of the moving fragments. It is necessary, however, to distinguish the ability to corrade from the rate of corrasion, which will be seen further on to depend largely on other conditions.

Weathering is not directly influenced by slope, but it is reached indirectly through transportation. Solution and frost, the chief agents of rock decay, are both retarded by the excessive accumulation of disintegrated rock. Frost action ceases altogether at a few feet below the surface, and solution gradually decreases as the zone of its activity descends and the circulation on which it depends becomes more sluggish. Hence the rapid removal of the products of weathering stimulates its action, and especially that portion of its action which depends upon frost. If, however, the power of transportation is so great as to remove completely the products of weathering, the work of disintegration is thereby checked; for the soil, which weathering tends to accumulate, is a reservoir to catch rain as it reaches the earth, and store it up for the work of solution and frost, instead of letting it run off at once unused.

In brief, a steep declivity favors transportation and thereby favors corrasion. The rapid, but partial, transportation of weathered rock accelerates weathering; but the complete removal of its products retards weathering.

(2.) Other things being equal, *erosion is most rapid when the eroded rock offers least resistance;* but the rocks which are most favorable to one portion of the process of erosion, do not necessarily stand in the same relation to the others. Disintegration by solution depends in large part on the solubility of the rocks, but it proceeds most rapidly with those fragmental rocks of which the cement is soluble, and of which the texture is open. Disintegration by frost is most rapid in rocks which absorb a large percentage of water and are feebly coherent. Disintegration by mechanical wear is most rapid in soft rocks. Transportation is most favored by those rocks which yield by disintegration the most finely comminuted debris

(3.) The influence of climate upon erosion is less easy to formulate. The direct influences of temperature and rainfall are comparatively simple, but their indirect influence, through vegetation, is complex, and is in part opposed to the direct influence of rainfall.

Temperature affects erosion chiefly by its changes. Where the range of temperature includes the freezing point of water, frost contributes its powerful aid to weathering; and it is only where changes are great and sudden that rocks are cracked by their unequal expansion or contraction.

All the processes of erosion are affected directly by the amount of rainfall, and by its distribution through the year. All are accelerated by its increase and retarded by its diminution. When it is concentrated in one part of the year at the expense of the remainder, transportation and corrasion are accelerated, and weathering is retarded.

Weathering is favored by abundance of moisture. Frost accomplishes most when the rocks are saturated; and solution, when there is the freest subterranean circulation. But when the annual rainfall is concentrated into a limited season, a larger share of the water fails to penetrate, and the gain from temporary flooding does not compensate for the checking of all solution by a long dry season.

Transportation is favored by increasing water supply as greatly as by increasing declivity. When the volume of a stream increases, it becomes at the same time more rapid, and its transporting capacity gains by the increment to velocity as well as by the increment to volume. Hence the increase in power of transportation is more than proportional to the increase of volume.

It is due to this fact chiefly, that the transportation of a stream which is subject to floods is greater than it would be if its total water supply were evenly distributed in time.

The indirect influence of rainfall and temperature, by means of vegetation, has different laws. Vegetation is intimately related to water supply. There is little or none where the annual precipitation is small, and it is profuse where the latter is great and especially where the temperature is at the same time high, In proportion as vegetation is profuse the solvent power of percolating water is increased, and, on the other hand, the ground is sheltered from the mechanical action of rains and rills. The removal of disintegrated rock is greatly impeded by the conservative power of roots and fallen leaves, and a soil is invariably preserved. Transportation is retarded. Weathering by solution is accelerated up to a certain point, but in the end it suffers by the clogging of transportation. The work of frost is nearly stopped as soon as the depth of soil exceeds the limit of frost action. The force of rain-drops is expended on foliage. Moreover a deep soil acts as a distributing reservoir for the water of rains, and tends to equalize the flow of streams.

Hence the general effect of vegetation is to retard erosion; and since the direct effect of great rainfall is the acceleration of erosion, it results that its direct and indirect tendencies are in opposite directions.

In arid regions of which the declivities are sufficient to give thorough drainage, the absence of vegetation is accompanied by

absence of soil. When a shower falls, nearly all the water runs off from the bare rock, and the little that is absorbed is rapidly reduced by evaporation. Solution becomes a slow process for lack of a continuous supply of water, and frost accomplishes its work only when it closely follows the infrequent rain. Thus weathering is retarded, and transportation has its work so concentrated by the quick gathering of showers into floods, as to compensate, in part at least, for the smallness of the total rainfall from which they derive their power.

Hence in regions of small rainfall, surface degradation is usually limited by the slow rate of disintegration; while in regions of great rainfall it is limited by the rate of transportation. There is probably an intermediate condition, with moderate rainfall, in which a rate of disintegration greater than that of an arid climate is balanced by a more rapid transportation than consists with a very moist climate, and in which the rate of degradation attains its maximum.

Having examined the conditions of erosion separately, let us now group them in such combination as will help to an understanding of the cañons.

Over nearly the whole of the earth's surface there is a soil, and wherever this exists we know that the conditions are more favorable to weathering than to transportation. Hence it is true in general that the conditions which limit transportation are those which limit the general degradation of the surface.

To understand the manner in which this limit is reached, it is necessary to look at the process by which the work is accomplished.

Transportation and Comminution.—A stream of water flowing down its bed expends an amount of energy that is measured by the quantity of water and the vertical distance through which it descends. If there were no friction of the water upon its channel the velocity of the current would continually increase; but if, as is the usual case, there is no increase of velocity, then the whole of the energy is consumed in friction. The friction produces inequalities in the motion of the water, and especially induces subsidiary currents more or less oblique to the general onward movement. Some of these subsidiary currents have an upward tendency, and by them is performed the chief work of transportation. They lift small particles from the bottom and hold them in suspension while they move forward with the general current. The finest particles sink most slowly and are carried farthest before they fall. Larger ones are barely lifted, and are dropped at once. Still larger are only half lifted; that is, they are lifted on the side of the current and rolled over,

without quitting the bottom. And finally there is a limit to the power of every current, and the largest fragments of its bed are not moved at all.

There is a definite relation between the velocity of a current and the size of the largest bowlder it will roll. It has been shown by Hopkins that the weight of the bowlder is proportioned to the sixth power of the velocity. It is easily shown also that the weight of a suspended particle is proportioned to the sixth power of the velocity of the upward current that will prevent its sinking. But it must not be inferred that the total load of detritus that a stream will transport bears any such relation to the rapidity of its current. The true inference is, that the velocity determines the limit in coarseness of the detritus that a stream can move by rolling, or can hold in suspension.

Every particle which a stream lifts and sustains is a draft upon its energy, and the measure of the draft is the weight (weighed in water) of the particle, multiplied by the distance it would sink in still water in the time during which it is suspended. If, for the sake of simplicity, we suppose the whole load of a stream to be of uniform particles, then the measure of the energy consumed in their transportation, is their total weight multiplied by the distance one of them would sink in the time occupied in their transportation. Since fine particles sink more slowly than coarse, the same consumption of energy will convey a greater load of fine than of coarse.

Again, the energy of a clear stream is entirely consumed in friction on its bottom; and the friction bears a direct relation to its velocity. But if detritus be added to the water, then a portion of its energy is diverted to the transportation of the load; and this is done at the expense of the friction upon the bottom, and hence at the expense of velocity. As the energy expended in transportation increases, the velocity diminishes. If the detritus be composed of uniform particles, then we may also say that as the load increases, the velocity diminishes. But the diminishing velocity will finally reach a point at which it can barely transport particles of the given size, and when this point is attained, the stream has its maximum load of detritus of the given size. But fine detritus requires less velocity for its transportation than coarse, and will not so soon reduce the current to the limit of its efficiency. A greater per cent of the total energy of the stream can hence be employed by fine detritus than by coarse.

Thus the capacity of a stream for transportation is enhanced by comminution in two ways. Fine detritus, on the one hand, consumes less energy for the transportation of the same weight, and on the other, it can utilize a greater portion of the stream's energy.

It follows, as a corollary, that the velocity of a fully loaded stream depends (*ceteris paribus*) on the comminution of the material of the load. When a stream has its maximum load of fine detritus, its velocity will be less than when carrying its maximum load of coarse detritus; and the greater load corresponds to the less velocity.

It follows also that a stream which is supplied with heterogeneous debris will select the finest. If the finest is sufficient in quantity, the current will be so checked by it, that the coarser cannot be moved. If the finest is not sufficient, the next grade will be taken, and so on.

Transportation and Declivity.—To consider now the relation of declivity to transportation we will assume all other conditions to be constant. Let us suppose that two streams have the same length, the same quantity of water, flow over beds of the same character, and are supplied to their full capacities with detritus of the same kind; but differ in the total amount of fall. Their declivities, or rates of fall, are proportional to their falls. Since the energy of a stream is measured by the product of its volume and its fall, the relative energies of the two streams are proportional to their falls, and hence, proportional to their declivities. The velocities of the two streams, depending as we have seen above, on the character of the detritus which loads them, are the same; and hence the same amount of energy is consumed by each in friction on its bed. And since the energy which each stream expends in transportation is the residual after deducting what it spends in friction from its total energy, it is evident that the stream with the greater declivity will not merely have the greater energy, but will expend a less per cent of it in friction and a greater per cent in transportation.

Hence declivity favors transportation in a degree that is greater than its simple ratio.

[There are two elements of which no account is taken in the preceding discussion, but which need to be mentioned to prevent misapprehension, although they detract in no way from the conclusions.

The first is the addition which the transported detritus makes to the energy of the stream. A stream of water charged with detritus is at once a compound and an unstable fluid. It has been treated merely as an unstable fluid requiring a constant expenditure of energy to maintain its constitution; but looking at it as a compound fluid, it is plain that the energy it developes by its descent, is greater than the energy pertaining to the water alone, in the precise ratio of the mass of the mixture to the mass of the simple water.

The second element is the addition which the detritus makes to the friction of the stream. The coefficient of friction of the compound stream upon its bottom will always be greater than that of the simple stream of water, and hence for the same velocity a greater amount of energy will be consumed.

It may be noted in passing, that the energy which is consumed in the friction of the detritus on the stream bed, accomplishes as part of its work the mechanical corrasion of the bed.]

Transportation and quantity of water.—The friction of a stream upon its bed depends on the character of the bed, on the area of the surface of contact, and on the velocity of the current. When the other elements are constant, the friction varies directly with the area of contact. The area of contact depends on the length and form of the channel, and on the quantity of water. For streams of the same length, and same form of cross-section, but differing in size of cross-section, the area of contact varies directly as the square root of the quantity of water. Hence, *ceteris paribus*, the friction of a stream on its bed, is proportioned to the square root of the quantity of water. But, as stated above, the total energy of a stream is proportioned directly to the quantity of water. And also, the total energy is equal to the energy spent in friction, plus the energy spent in transportation. Whence it follows, that if a stream change its quantity of water without changing its velocity or other accidents, the total energy will change at the same rate as the quantity of water, the energy spent in friction will change at a less rate, and the energy remaining for transportation will change at a greater rate.

It follows, as a corrollary, that the running water which carries the debris of a district, loses power by subdivision toward its sources; and that, unless there is a compensating increment of declivity, the tributaries of a river will fail to supply it with the full load which it is competent to carry.

It is noteworthy also, that the obstruction which vegetation opposes to transportation, is especially effective in that it is applied at the infinitesimal sources of streams, where the force of the running water is least.

A stream which can transport debris of a given size, may be said to be *competent* to such debris. Since the maximum particles which streams are able to move are proportioned to the sixth powers of their velocities, competence depends on velocity. Velocity, in turn, depends on declivity and volume, and (inversely) on load.

In brief, the capacity of a stream for transportation is greater for fine debris than for coarse.

Its capacity for the transportation of a given kind of debris is enlarged in more than simple ratio by increase of declivity; and it is enlarged in more than simple ratio by increase of volume.

The competence of a stream for the transport of debris of a given fineness, is limited by a correspondent velocity.

The *rate* of transportation of debris of a given fineness, may equal the capacity of the transporting stream, or it may be less. When it is less, it is always from the insufficiency of supply. The supply which is furnished by weathering is never available unless the degree of fineness of the debris brings it within the competence of the stream at the point of supply.

The chief point of supply is at the very head of the flowing water. The rain which falls on material that has been disintegrated by weathering, begins, after it has saturated the immediate surface, to flow off. But it forms a very thin sheet; its friction is great; its velocity is small; and it is competent to pick up only particles of exceeding fineness. If the material is heterogeneous, it discriminates and leaves the coarser particles. As the sheet moves on, it becomes deeper, and soon begins to gather itself into rills. As the deepening and concentration of water progresses, either its *capacity* increases and the load of fine particles is augmented, or, if fine particles are not in sufficient force, its *competence* increases, and larger ones are lifted. In either case the load is augmented, and, as rill joins with rill, it steadily grows, until the accumulated water finally passes beyond the zone of disintegrated material.

The particles which the feeble initial currents are not competent to move, have to wait either until they are subdivided by the agencies of weathering, or until the deepening of the channels of the rills so far increases the declivities, that the currents acquire the requisite velocity, or until some fiercer storm floods the ground with a deeper sheet of water.

Thus rate of transportation, as well as capacity for transportation, is favored by fineness of debris, by declivity, and by quantity of water. It is opposed chiefly by vegetation, which holds together that which is loosened by weathering, and shields it from the agent of transportation in the very place where that agent is weakest.

When the current of a stream gradually diminishes in its course—as, for example, in approaching the ocean—the capacity for transportation also diminishes; and so soon as the capacity becomes less than the load, precipitation begins,—the coarser particles being deposited first.

Corrasion.—If a stream has no load of detritus, it corrades only by solution. If it is loaded to its full capacity, it does

not corrade; it is on the verge between corrasion and deposition. Only with a partial load does a stream wear its bottom.

The rapidity of mechanical corrasion depends on the hardness, size, and number of transient fragments, on the hardness of the rock-bed, and on the velocity of the stream. The blows which the moving fragments deal upon the stream-bed are hard, in proportion as the fragments are large and the current is swift. They are most effective when the fragments are hard and the bed-rock is soft. Their number is increased, up to a certain limit, by the increase of the load of the stream; but when the fragments become greatly crowded at the bottom of a stream, their force is partially spent among themselves, and the bed-rock is in the same degree protected. For this reason, and because increase of load causes retardation of current, it is probable that the maximum work of corrasion is performed when the load is far within the transporting capacity.

The element of velocity is of double importance, since it determines, not only the speed, but, to a great extent, the size of the pestles which grind the rocks. The coefficients upon which it in turn depends, namely, declivity and quantity of water, have the same importance in corrasion that they have in transportation.

Let us now direct our attention to the region of the cañons.

The Plateau province lay beneath the ocean up to the close of the Mesozoic age. In early Cenozoic time it was nearly covered by fresh-water lakes, and was not greatly elevated.

In more recent epochs it has been very greatly, but unequally lifted, and the lakes have been drained. The erosion which began with the first lifting of a part above the ocean, and extended its area as the lakes disappeared, has progressed continually to the present time. The average total uplift has been about 12,000 feet; the mean altitude of the present surface is about 7,000 feet; and the difference is the mean amount of degradation. While 5,000 feet have been removed from the general surface, an amount greater by several thousand feet has been corraded by the rivers.

The greater tributaries of the Colorado have their sources in elevated mountains which are well supplied with rain. Their courses through the Plateaus traverse regions characterized by aridity.

On the uplands which border the cañons the supply of water is so small and the declivity is so great that weathering is less favored than transportation. No soil accumulates; vegetation is scant; and, for the lack of these, weathering is reduced to a minimum. The degradation of the surface is limited by the retarded weathering.

In the cañons corrasion is favored by a quantity of water which belongs to the mountain sources of the streams and not to the plateaus which they divide. It is favored by a great declivity of bed, for which it is indebted to the magnitude and recency of the uplift. It is favored by a moderate supply of debris, always sufficient for the work of excavation, but not so great as to consume the entire energy of the current.

The contrast between the degradation of the upland and the cutting of the water ways is strongest where the rocks are best fitted to resist disintegration. The rivers sink their channels into the land in a harmonious and interdependent system, and cannot excavate soft beds more deeply than hard. But the only downward limit to the degradation of the tables is the level of the draining river system; and the varying retardation which it suffers from the resistance of different rocks, is expressed in the varying height of the cañon walls.

A second problem which has arisen in the study of the erosion of the Plateaus may be called

The Problem of Waterfalls.

Where rivers descend a slope that is terraced by the alternation of hard and soft strata, they are apt to leap from the edges of the hard beds in waterfalls. But the Colorado, notwithstanding the structure of its bed presents the most favorable conditions, makes no leap. At the head of Marble Cañon, for instance, the river crosses a great bed of limestone, lying nearly level and underlaid by a great bed of friable sandstone. The limestone resists all erosive agents as strongly as does the Niagara limestone, and the sandstone yields to them as easily as does the Niagara shale. But, instead of plunging from one to the other in a great cataract, the Colorado cuts the two with nearly equal grade of channel. Its average descent in the hard rock is ten feet to the mile, and in the soft, less than five feet.

It is evident that for the production of waterfalls some condition is involved beside that of the constitution of the rock-system which the stream traverses,—some condition that pertains to the constitution of the stream itself. Such a condition is to be found in the relation of corrasion to transportation.

Let us suppose that a stream, endowed with a constant supply of water, is at some point continuously supplied with as great a load as it is capable of carrying. For so great a distance as its velocity remains the same, it will neither corrade nor deposit, but will leave the grade of its bed unchanged. But if in its progress it reaches a place where a less declivity of bed gives a diminished velocity, its capacity for transportation will become less than the load, and part of the load will be depos-

ited. Or if in its progress it reaches a place where a greater declivity of bed gives an increased velocity, the capacity for transportation will become greater than the load, and there will be corrasion of the bed. In this way a stream, which has a supply of debris equal to its capacity, tends to build up the gentler slopes of its bed and cut away the steeper. It tends to establish a single, uniform grade.

Let us now suppose that the stream, after having obliterated all the inequalities of the grade of its bed, loses nearly the whole of its load. Its velocity is at once accelerated and corrasion begins through its whole length. Since the stream has the same declivity, and consequently the same velocity, at all points, its capacity for corrasion is everywhere the same. Its rate of corrasion, however, will depend on the character of its bed. Where the rock is hard, corrasion will be less rapid than where it is soft, and there will result inequalities of grade. But so soon as there is inequality of grade, there is inequality of velocity, and inequality of capacity for corrasion; and where hard rocks have produced declivities, there the capacity for corrasion will be increased. The differentiation will proceed until the capacity for corrasion is everywhere proportioned to the resistance, and no farther,—that is, until there is an equilibrium of action.

In general, we may say that a stream tends to equalize its work in all parts of its course. Its power inheres in its fall, and each foot of fall has the same power. When its work is to corrade and the resistance is unequal, it concentrates its energy where the resistance is great, by crowding many feet of descent into a small space; and diffuses it, where the resistance is small, by using but a small fall in a long distance. When its work is to transport, the resistance is constant, and the fall is evenly distributed by a uniform grade. When its work includes both transportation and corrasion, as is the usual case, its grades are somewhat unequal; and the inequality is greatest when the load is least.

The condition of the Colorado in respect to load, is midway between that of the Niagara and that of the Platte.

The water of the Niagara is nearly devoid of load. The lake of which it is the outlet gathers the detritus of all tributary streams, and only on the occasion of a great storm yields a small portion of it to the Niagara. The work of transportation is at a minimum, and the differentiation of slope dependent on rock structure reaches its maximum in a cataract.

The water of the Platte is supplied with all the load it can move. Major Powell, who has made a careful study of this river, ascribes its peculiar character to the fact that it flows through a region of unconsolidated strata. Its mean declivity

is as great as that of the Colorado, and it would have carved cañons of imposing depth, if only the material of its banks were sufficiently coherent to stand in walls. As it is, the loose sands of the bordering plains are washed and blown into the river, and, its energy being consumed in their transportation, the corrasion of its channel can proceed no faster than the general degradation of the plain. Having little work to perform beside the transportation of its load, it maintains an almost unvaried slope from the foot of the mountains to its mouth.

In that portion of the Colorado which is contained in the Plateau province, the load consumes a share of the energy of the stream and leaves to corrasion the remainder. The slopes of the stream-bed are varied, but not so greatly as those of the Niagara. Where the bed-rock is soft, the declivity is small. Where it is hard, the declivity is relatively great; but in the toughest hornblende rock the mean angle of slope does not exceed three degrees.

The Problem of Inconsequent Drainage.

There is a third problem of erosion now under investigation in the Plateaus that promises results of value and novelty. It was propounded by Major Powell, and is set forth on page 162, *et seq.*, of his "Exploration of the Colorado River." The question to be answered is: What is the relation of the drainage system of the Plateaus to the system of displacements? How far is it *consequent*, how far *antecedent*, how far *super-imposed?*

If a series of sediments, accumulated in an ocean or lake, be subjected to a system of displacements while still under water, and then be converted to dry land by elevation *en masse*, or by the retirement of the water, the rains which fall on it will inaugurate a drainage system perfectly conformable with the system of displacements. Streams will rise along the crest of each anticlinal, will flow from it in the direction of the steepest dip, will unite in the synclinals, and will follow them lengthwise. The axis of each synclinal will be marked by a watercourse; the axis of each anticlinal by a watershed. Such a system is said to be *consequent* on the structure.

If, however, a system of displacements affect a rock series after the series has become continental, it will have already acquired a system of waterways, and, unless the displacements are produced with unusual rapidity, the waters will not be diverted from their accustomed ways. The effect of local elevation will be to stimulate local corrasion, and each river that crosses an uplifted block will, inch by inch as the block rises, deepen its channel and valorously maintain its original course. It will result that the directions of the drainage lines will be

independent of the displacements. Such a drainage system is said to be *antecedent* to the structure.

There is one other case. Suppose a rock series that has been folded and eroded, to be again submerged, and to receive a new accumulation of unconforming sediments. Suppose further, that it once more emerges, and that the new sediments are eroded from its surface. Then the drainage system will have been given by the form of the upper surface of the superior strata, but will be independent of the structure of the inferior series into which it will descend vertically as the erosion progresses. Such a drainage system is said to be *super-imposed* upon the structure of the older series of strata.

A large share of the drainage of the Plateaus is not consequent. How much is super-imposed, and how much antecedent remains to be determined. With the solution of the problem are involved the determination of the antiquity and history of the Green and Colorado Rivers, and the physical history of the great Tertiary lakes; and we may hope that from its discussion will result the establishment of laws, by the aid of which it shall be possible, in other regions, to deduce facts of geological history from an examination of the relation of structure to drainage.

Summary.

The exposure of the rock structure in the Colorado Plateau province is exceptionally thorough. Soil and vegetation obstruct the view less than in other lands, and deep cañons exhibit natural sections in many directions.

The rock structure is simple but not the simplest. The strata have been displaced, but their displacement is so little complex that it can be clearly determined in kind and amount.

In virtue of the simplicity of structure and continuity of exposure, the geologist does not have to put fragmentary data together and grope for the general facts of which they form part, but is able to see all the parts combined in nature in visible wholes. Nothing need be left for doubtful interpretation where everything can be seen; and with the facts of structure conspicuous and beyond question, the mind is left free to search for causes.

The facilities for the study of single, simple displacements, isolated from other phenomena of the same order, are equalled by those for the study of eruptive mountains which are at once simple, isolated, and dissected by erosion.

To the student of stratigraphy are offered continuous exposures of great length.

To the student of erosion are exhibited the most distinguished monuments of its action; and he is given an opportu-

nity to partially isolate certain of the conditions which control the rapidity of erosive action, by viewing their influence where that influence is at a maximum.

No attempt has been made in this brief review to indicate the entire range of the subjects that will interest the geological student of the region. It was proposed rather to call attention to those categories of phenomena which give greatest promise of affording contributions to the body of principles which constitute the science of geology,—as distinguished from the phenomena which will merely enlarge the body of facts upon which its established principles are based. The progress of geological exploration has compassed so small a fraction of the earth's surface that the aspect of the science is modified, in greater or less degree, by the addition of each important mass of facts; and when the contribution from the Plateaus shall have been made, I am confident that its record will find a place in the history of geological progress.

Already the field has yielded to its students results which are new to them, and which are probably new to the world of science. Among them are a type of uplifted mountains, a type of eruptive mountains, a theory of waterfalls, and a classification of drainage systems.

ART. XI.—*Note on the development and homologies of the anterior brain-mass with Sharks and Skates;** by Prof. BURT G. WILDER.

IN the paper to which I have just referred† are some statements, partly original and partly based upon the authority of others, which, after a comparison of the preparations before you ‡ I now believe to require modification.

1. *The structure of the so-called lobe and crus.*—Accepting the common belief (as stated by Owen) that "in sharks a ventricle is continued to each rhinencephalon along its crus from the

* Part of a lecture on the brains of Plagiostomes (one of a course upon the brains of the fish-like Vertebrates, to the special students of Natural History at Cornell University) delivered May 23d, 1876.

† Notes on the American Ganoids, *Amia*, *Lepidosteus*, *Acipenser* and *Polyodon*. I. On the respiratory actions of *Amia* and *Lepidosteus*. II. On the transformations of the tail of *Lepidosteus*. III. On the transformation of the pectoral fins of *Lepidosteus*. IV. On the brains of *Amia*, *Lepidosteus*, *Acipenser* and *Polyodon*. Proc. Am. Assoc. Adv. Sci., 1875, 151–194; 3 plates.

‡ These comprised brains, entire or more or less dissected, of the following forms: *Mustelus lævis*, fœtal, young, and adult; *Acanthias vulgaris*, fœtal, and adult; *Zygæna*, fœtal, and adult; *Carcharias obscurus* (three examples); *Triakis semifasciatus*; *Odontaspis Americanus* (three examples); *Raia* (sp. ?); *Myliobatis bispinosus*; *Torpedo* (sp. ?).

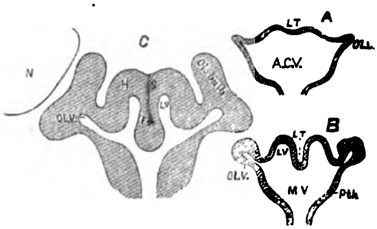
prosencephalon," I was led to conclude that the small hollow bud from the side of the anterior brain-mass (evidently the slightly modified anterior cerebral vesicle) of the fœtal *Mustelus* must elongate and expand at its tip in contact with the olfactory sack so as to form the lobe and crus; page 182. But the young and adult brains since examined show that the ventricle ends as a rounded *cul-de-sac* before reaching the "lobe." The same is the case in *Acanthias* and others with short "crura." In *Myliobatis*, *Carcharias* and others it is even more apparent that the greatly elongated crura are merely bundles of nerve *fibers*, the distal expansion of which forms the so-called lobe. Should there be found ganglionic tissue intermingled with the fibers there would be reason for closer comparison of the mass with the retina of the eye, but not, it seems to me, for regarding it as serially homologous with the optic lobe as a part of the brain. The true olfactory lobe or rhinencephalon seems therefore to embrace only the hollow base of the crus, more or less thickened and more or less distinguishable from the main mass as a conical process. The olfactory bulb, with the more or less elongated crus of many Plagiostomes, seems to be developed independently or in connection with the olfactory sack as are the general nerves. But it is very desirable to trace their formation in forms having long olfactory crura.

2. *The development and position of the hemispheres.*—If the foregoing conclusion be correct, the hemispheres of sharks and skates must be sought for elsewhere than in the thickened and hollow bases of the so-called olfactory crura. The entire anterior mass has been regarded by some as the coalesced hemispheres; and some foundation for this is afforded by the more or less distinct median furrow on its exposed surfaces. But in the adult preparations before you this furrow does not extend over the hinder part of the mass. In several its posterior termination is indicated by a vascular foramen apparently extending vertically through the brain. In the young *Mustelus* and fœtal *Acanthias* the furrow is an actual *fissure* as far back as the foramen above mentioned. The fœtal *Mustelus* presents only a shallow median depression upon the front of the anterior vesicle. Finally the horizontal sections and the dissections show the existence in some adults of the following cavities or ventricles:

A. The y-shaped remnant of the cavity of the anterior vesicle reduced by the great thickening of the walls; the posterior arm opens into the third ventricle behind; the two anterior communicate with the secondary ventricles. B. The olfactory ventricles, continued for a greater or less distance into the olfactory lobes. C. Ventricles, one on each side extending forward and usually inward within the lateral masses separated by the

furrow or fissure. D. In *Odontaspis* and some others there are posterior prolongations of the ventricle upon a higher plane than the anterior horns of the original cavity.

A fuller series of fœtal brains is required for absolute demonstration, but the appearances above described suggest the following conclusion: The hinder part of the mass corresponds to the *prothalami* of Ganoids. The true hemispheres are the lateral masses more or less completely fused on the middle line (as are the olfactory lobes of frogs and toads,) and sometimes developing at the plane of union a bundle of longitudinal commissural fibers. The hemispheres retain their typical condition as anterior protrusions of the anterior vesicle; but they lie mesiad of the olfactory lobes, and, in *Mustelus* at least, seem to be formed after them. It seems probable therefore that the commonly accepted definitions of the hemispheres and the olfactory lobes must be modified with reference to the conditions here indicated:—the latter being developed first and directly from the anterior cerebral vesicle; the former to the inner or mesial side of the olfactory lobes. Their relative positions are thus the reverse of what they are in *Petromyzon*, notwithstanding the other points of resemblance between the Plagiostomes and the Myzonts.



Explanation of Figures.

Figure I.—Diagrams of sections of the large median anterior brain-mass of sharks. A. From embryo *Mustelus* 37 mm. long. Horizontal section (enlarged) of the thin-walled mass which seems to be the slightly modified front and larger portion of the anterior cerebral vesicle. (In Ganoids and Teleosts this mass seems to divide above so as to form the lateral masses called by me *prothalami*). OLL. The commencing olfactory lobes. L.T. The center of the *lamina terminalis* or anterior wall of the vesicle. On each side the wall protrudes slightly.

B. From fœtal *Acanthias* 16 cm. long. Horizontal section, enlarged. The walls are thicker; the olfactory lobes are larger, and the lateral protrusions of the lamina terminalis are much more extensive.

C. From an adult *Mustelus*. The olfactory lobe has either expanded into or become connected with a large crescentic bulb into which the ventricle does not extend. The lateral protrusions (H) are closely united by their mesial surfaces at the suture (S). The foramen (F) marks the position of the median line of the lamina terminalis. The cavities are much reduced by the thickening of the walls.

ART. XII.—*New form of Compensating Pendulum;* by J. LAWRENCE SMITH, Louisville, Ky.

IN the construction of this new form of compensating pendulum, I have taken advantage of the very great expansibility of that combination of sulphur and caoutchouc known as vulcanite or ebonite. Its coefficient of expansion is known to approach that of mercury in the ranges of temperature from 0° to 70° C.

The mechanical arrangement adopted is a very simple one. The rod of the pendulum is of round steel, with an adjusting screw at the lower end: a round rod of vulcanite with a hole in the center is passed on to the steel rod, fitting it loosely, and being held in place by the adjusting screw. The bob of the pendulum consists of a heavy mass of brass with a hole through the center large enough to admit the vulcanite over which it passes, and by a properly arranged stop, rests on the end of the vulcanite farthest from the lower end of the pendulum, so that any expansion of the vulcanite elevates the brass bob, thus compensating for the downward expansion of the steel rod and brass bob.

There is a simple mechanical arrangement for adjusting the proper difference between the length of the vulcanite and the other parts of the pendulum.

For a second pendulum to an astronomical clock, I have used the following dimensions: diameter of the steel rod 6 mm.; diameter of vulcanite, 25 mm.; length of same, 165 mm.; diameter of brass bob, 63 mm; length of the same, 156 mm. These dimensions are in no way insisted on as being the best. For a half second pendulum I have used a steel rod 3 mm. in diameter; vulcanite 11 mm. in diameter and 63 mm. long; brass bob 38 mm. in diameter and 57 mm. long.

I have had one of these pendulums attached to an astronomical clock, and after adjustment it has been running four months with very satisfactory results. Should this form of pendulum prove itself constant and correct, it would certainly be a convenient one for transportation, and very much less costly than the ordinary form. And as for the half-second pendulum, in such constant use in mantle clocks, it will be of the greatest service and not add more than 20 cents cost to the commonest form of pendulum that can be used.

As regards the uniformity of the coefficient of expansion of all vulcanites, of course it is not to be supposed that it can be relied upon, but a very simple method is used to ascertain it for any single specimen, or for a number made of the same lot of material.

I have made experiments on several different specimens, and the results vary little from each other. The range of temperature with which the experiments were made was from zero to 43° C., on a bar 25 mm. in diameter, and 304 mm. long, this expanding in length 9–10 mm.; making the entire expansion equal to $\frac{1}{126}$ of the entire length of the rod for a temperature ranging from freezing to boiling point, giving as coefficient for linear expansion for one degree centigrade 0·000079365. This coefficient is seen to be lower than that of mercury; but from the fact that mercury corrects the pendulum by only one-half its expansion, and the vulcanite is made to correct it by its entire expansion, the length of vulcanite required is even less than the column of mercury used in the mercurial pendulum. This instrument is one whose use depends on its accuracy of operation after careful trial for some time.

ART. XIII.—*Aragonite on the surface of a meteoric iron, and a new mineral* (*Daubréelite*) *in the concretions of the interior of the same;* by J. LAWRENCE SMITH, Louisville, Ky.

I. *Incrustation of Aragonite.*

THE remarks in this communication have reference to some of the masses of iron that have been brought from that region of Mexico called the *Bolson de Mapini*, or the Mexican desert, situated in Cohahuila and Chihuahua, two of the northern provinces of Mexico; the desert being four hundred miles from east to west, and five hundred miles from north to south, bordering on the Rio Grande. This region, so prolific in masses of meteoric iron, has been described by Prof. Burckhardt of Bonn as well as by myself.

In 1854 I described three of the masses (this Journal, vol. xxviii, pp. 409); two of these have been brought to the United States, one weighing 125 kilograms and the other 630 kilograms. In 1868, eight others were brought to this country, the heaviest weighing 325 kilograms. These I described in 1869 (this Journ., Nov., 1869); and in 1871 I was enabled to give a description and an analysis of a still larger one weighing about 3500 kilograms, this last one remaining on the western boundary of the desert near El Para.

We have some account of one even larger than the last, located in the very center of the desert. So far as known there have been found in this locality not less than 15,000 kilograms of meteoric matter, an amount exceeding that which has been brought together in cabinets from all other sources.

When I examined the eight masses in 1868, I noticed a white crust on a small part of the surfaces of two of them, but at that time I could not make any critical examination of it. Within the past few months, these irons have come under my control, and therefore I have been enabled to examine the points that had been omitted, the most interesting of which forms the subject of this communication.

On one of these masses of iron, weighing 210 kilograms, there is a small amount of a white incrustation covering about 15 square centimeters of the surface: and on another, weighing 275 kilograms, there is an incrustation, which covered originally over 200 square centimeters of the surface, attached firmly to the iron, and when broken off (as most of it has been by careless handling of the mass), it brings away with it on the under surface a portion of the iron that has become oxidized: its thickness is from one to five millimeters.

It is quite hard, scratching calc spar very readily; the surface of it is irregular and granular. If broken perpendicularly to the surface of the iron and ground down, it will receive a very good polish, showing an irregular and wavy structure on many of the pieces, and parallel to the surface of the iron, with yellow and dark brown streaks like the Gibraltar limerock; it effervesces with acids, and is an incrustation of aragonite.

The following is the composition of the mineral:

Carbonate of lime	93·10
Sesquioxide of iron	1·00
Magnesia	*trace*
Insoluble residue	4·60
Water	1·00

As regards its formation, I am satisfied that the crust has been made on the iron since the fall of the latter. Conceiving this to be the case, I desired to know the nature of the rock and soil where these meteorites were found, and I have been able to gather the following particulars from Dr. Butcher who collected the specimens under examination. This spot is in an alluvial valley or plain between two ranges of high mountains running parallel with each other varying in distance from one to three miles. The mountains at the base are calcareous in formation, and in the hills and plains there are large calcareous deposits. The plain in many places is cut up with deep ravines, and several of the specimens of iron were found among the stones and sand at the bottom of the ravines, and during heavy rains were washed or covered with water. It is however only in wet seasons that the water is found remaining in the ravines and depressions of the valley, and this water is always brackish to the taste, containing a large amount of mineral matter.

Without giving any further details of the nature of this region of Mexico where these meteorites were collected, sufficient has been stated to show the probable source of the calcareous incrustation which I discovered upon two of them.

This incrustation on meteorites has been discovered but twice before, and in both instances by myself. One of them, however, is of so obscure and unsatisfactory a character that I have not given any public notice of it. The other is the case of the Newton County meteorite described by me (this Journal, II, vol. xl, 1865). It is a meteoric stone belonging to the variety classified by M. Daubrée as Syssidères; specimens of it have been furnished by me to the museums of the Garden of Plants, Great Britain and Vienna, with this incrustation in well defined particles of a translucent character adhering firmly to the surface. The entire amount of this meteorite yet known does not exceed 700 grams, although the primitive mass must still exist in a sparsely settled region of Arkansas, and when obtained will no doubt furnish specimens with a larger amount of the calcareous incrustation upon it.

2. *New Meteoric Mineral, Daubréelite.*

Two of the masses of iron above referred to have been cut across, the section made on one of them being over fifteen square decimeters; also several transverse cuts have been made. In all of these sections a number of nodular concretions have been exposed, most of them quite small, and hardly any exceeding a centimeter in diameter. At the first glance all these nodules have the appearance of very finely crystallized troilite; but a little closer inspection reveals the fact that most of these nodules have more or less of a black mineral associated with it. I had never seen anything of the kind before, it being very evident that it was not graphite. As further examination has proved it to be a new and interesting mineral, I have thought proper to designate it after M. Daubrée, who has done so much in the study and elucidation of meteoric minerals.

Daubréelite is a black lustrous mineral, highly crystalline in structure, occurring on the borders of the troilite nodules, and sometimes running across the center of them, as may be seen in one of the specimens, where, in a nodule of troilite, a vein of the mineral traverses the very center of the nodule, which is two millimeters in width and twelve millimeters long. It has a distinct cleavage, but I cannot make out its crystalline form. It is very fragile, and in the attempt to detach it from the iron, it breaks up into small fragments resembling small particles of molybdenite. It is feebly attracted in very fine particles when a strong magnet is brought in contact with it. This may arise from the presence of a minute quantity of troilite which it is

very difficult to get rid of. Pulverized, it furnishes a perfectly black powder, the smallest particle of which gives before the blowpipe a very strong reaction of chromium. Heated very intensely, it loses its brilliant color and becomes a dull black.

The powdered mineral is dissolved completely in nitric acid. The solution is intensely green, and furnishes a strong reaction of sulphuric acid and oxide of chrome. The other strong acids attack it but slightly.

This solubility in nitric acid readily distinguishes it from chrome iron. The quantity of mineral I was enabled to obtain pure, or nearly so, was very small, the reaction of the acids on the mineral being nearly the same as on troilite. I am enabled to separate them only by varying the strength of the acids, and the length of the time they are in contact with the minerals.

Less than one hundred milligrams were obtained of sufficient purity to make out its composition, and this amount furnished me 36·48 per cent of sulphur; the remainder was chrome with nearly ten per cent of iron, and a little carbonaceous matter. This mineral when obtained pure and in sufficient quantity for a thorough analysis (which I hope to make before long), will, I am satisfied, prove to be a protosulphide of chrome. The iron present being mixed with the Daubréelite. The following therefore would express its true composition: Sulphur 37·62, chrome 62·38.

This mineral is an interesting one, and is found in a very strange place, yet from what is revealed to us by the spectroscope with regard to the vapors surrounding the sun, the element chrome must be widely diffused in the matter of the universe.

ART. XIV.—*On some of the changes in the Physical Properties of Steel, produced by Tempering;* by A. S. KIMBALL, Prof. of Physics in the Worcester Institute of Industrial Science.

A FEW interesting, and, to a certain extent, novel results have recently been developed in our laboratory, which I venture to present in their present incomplete form, since the pressure of other duties will postpone, for a few months, further investigations in this direction. Up to the present time the larger number of our experiments have been made upon the behavior of tempered bars under a transverse stress, although a few qualitative trials have been made upon changes in electric conductivity and coefficients of expansion.

I. *The modulus of elasticity decreases as the hardness of the steel increases; in other words the harder the bar, the greater the deflection produced by a given weight.*

Many manuals of practical mechanics give a higher modulus for tempered than for untempered steel. Reuleaux in "Der Constructeur," (page 4,) states that it may be increased 50 per cent by hardening. Coulomb and Tredgold state that hardening has no influence whatever, while Styffe finds that the modulus is diminished. For our first experiment, five pieces of good tool-steel, each 13″ long, were cut from a half-inch square bar. These were carefully annealed, squared, and polished. No. 1 was laid aside and the others were hardened in cold water in the usual manner; No. 2 was "drawn" on a hot plate to a dark blue; No. 3 to a purple; No. 4 to a straw color; No. 5 was left hard. The modulus of elasticity was then determined by measuring the deflection produced by a weight applied at the middle of the bar. The probable error of the experiments did not exceed $\frac{1}{3}$ of one per cent. The experiment was varied in many ways, several qualities of steel and bars of different dimensions were employed with uniform results. In some grades of steel a difference of more than 10 per cent has been found between the modulus of the hardened and that of the annealed bar.

II. *The increase of deflection in a given time is greater, the harder the steel.*

It is well known that the deflection of a bar left under stress will increase for a long time. I am not aware, however, that comparative tests of the rate of increase in steel of different tempers have previously been made.

III. *The immediate set increases with the hardness of the steel.*

In the experiments each bar was of course loaded with the same weight which was allowed to act for the same number of minutes.

IV. *A bar recovers from a temporary set with greater rapidity the harder it is.*

The remarkable fluctuations in the line of the bar observed by Prof. Norton, (this Journal, April, 1876,) became more marked and had a wider range as the hardness of the bar increased. In none of the experiments referred to was a permanent set produced, though in some cases 48 hours had elapsed before the bar recovered its original line. In a few experiments an attempt was made to determine the approximate hardness of the bars by grinding. The results obtained, however, could not be considered very reliable. A more satisfactory method was found in the determination of the temperatures employed in hardening and drawing, by the specific heat of platinum, or by the use of the pyrometer.

I am indebted to Mr. F. C. Blake for the accuracy with which the experiments referred to in this note, have been conducted.

ART. XV.—*A Glass Circle for the measurement of Angles;* by LEWIS M. RUTHERFURD.

AT the summer meeting of the National Academy of Sciences, in the year 1866, I described the micrometer which I had constructed for the measurement of astronomical photographs. It was capable of measuring angles of position, and also distances in directions at right angles to each other. These last measurements were made by aid of screws arranged after the manner of those of an ordinary slide rest: these screws were constructed with great care and I had good reason to be satisfied with the smallness of their errors.

At the Spring meeting of the Academy, for the year 1870, I explained that I had been obliged to give up the idea of using screws on account of the rapid changes in their errors caused by friction and consequent wear, and I then stated that I intended to discard the screw and the compressed slide, and substitute for them a divided glass scale, to be read by a micrometer microscope, and a gravity slide with one V and one flat slide. This intention I carried out during the year, the new form being first used about the month of March, 1871. It has been constantly used since that time, and continues to give great satisfaction. The success of this divided glass scale confirmed me in a determination of long standing to try the experiment of substituting a glass circle for one of metal in some instrument for the measure of angles of precision.

Two years absence in Europe and other occupations conspired to postpone the execution of this plan until the past winter, during which it has been realized with what seems to me the most promising success. I had in my possession a spectrometer by Bruner of Paris—his small model, similar to the one used by Mascart, and figured in his paper on the measures of wave lengths. This instrument has a good steel center and was furnished with a circle divided on silver reading by means of the verniers to 10″. The diameter of the circle is small, not quite seven inches, and the inability to read smaller angles has always been its weak point. I have substituted for this metallic circle, one of glass about ten inches in diameter divided by Mr. Stackpole to ten minutes of arc, and read by two micrometer microscopes magnifying seventy-five times; each revolution of the screws being equivalent to one minute, the drums being divided into sixty parts, read to seconds with easy estimate of fractions—each degree line is numbered so as to be visible in the field of the microscope. I was able to furnish to Mr. Stackpole a well tried diamond which has made lines of the greatest delicacy, being much finer

as seen in the microscopes than the spider lines, by means of which the bisections are made. The advantages of this system are obvious, viz: perfection of surface permitting a line of any desired fineness—facility of illumination permitting the extension of the power of the reading microscopes to several hundred times—smallness of dimensions and consequent cheapness and avoidance of almost all the questions of flexure and local effects of temperature.

I am convinced from the ease with which one second is read on my instrument, with microscopes only 4¾ inches long including objectives and eye-pieces, that upon a circle of fifteen inches provided with powerful microscopes, greater precision could be attained in the reading of angles than with the largest metallic circles now in use.

For the purpose of showing the degree of precision attainable, I add two series of bisections of lines on the circle made by myself, and two made by a lady, marked respectively R. and M.

	R.	R.	M.	M.
	7″·5	1″·8	23″·6	11″·
	7 ·4	1 ·3	23 ·6	11 ·2
	7 ·7	1 ·9	23 ·3	11 ·8
	7 ·4	1 ·8	23 ·8	11 ·
	7 ·3	1 ·8	24 ·5	10 ·9
	7 ·6	1 ·8	23 ·9	11 ·5
	7 ·7	1 ·9	23 ·7	11 ·5
	7 ·4	2 ·	24 ·	11 ·5
	7 ·6	2 ·3	23 ·9	11 ·
	7 ·8	2 ·3	24 ·3	11 ·4
Mean,	7″·54	1″·89	23″·86	11″·28

It will be readily seen that the probable error of any single reading in any one of these series is considerably less than half a second, while the probable error of the mean of any series is a much smaller fraction.

New York, June 1, 1876.

Art. XVI.—*Friedrich Wilhelm August Argelander.**

Friedrich Wilhelm August Argelander was born at Memel, in East Prussia, on the 22d March, 1799. His father, who was of Finnish descent, was a merchant of that town, whilst his mother belonged to a German family. Their circumstances were such as enabled them to give their son a very careful

* This notice is principally an abstract of that by Prof. Schönfeld in *Vierteljahrsschrift der Astronomischen Gesellschaft*, Jahrgang x, part 3, and is here cited from the "Monthly Notices" of the Astronomical Society.

training and education. Political events brought him into very early connection with historic names. After the battle of Jena the Prussian royal family left Berlin, and took up their abode for some time at Memel. The Crown Prince (afterwards King Frederick William IV.) resided at the house of Argelander's father, and formed there a strong and lasting friendship with the future Professor. Scarcely less intimate were his relations with Prince William, the present Emperor of Germany.

In due course young Argelander was sent to the gymnasium at Elbing, and in 1813 to the Collegium Fredericanum at Königsberg, from which, in April, 1817, he proceeded to the University of that town. Although from the first a diligent student, he did not show any special taste for the science in which he was to become so famous until he was attracted thereto by the lectures of Bessel. This led him to request the latter to entrust him with some calculations for the Observatory. The *Fundamenta Astronomiæ* had then been just completed; but Bessel put into his hands the reduction of the observations of 67 stars observed by himself at Königsberg, and not previously observed since Bradley, and also the determination of the latitude of the Observatory from observations of circumpolar stars. The results of these labors were published in the 5th part of the Königsberg Observations, in which he introduced our late Associate to the scientific world as "one of his most distinguished pupils." Other calculations followed, and it was not long before Argelander took part also in the observations; the first of importance being that of the occultation of the *Pleiades* on the 29th of August, 1820. Soon after that, on the 1st of October, he was regularly appointed as Bessel's assistant at the Observatory—the beginning of a career in which he enriched astronomy with results such as could only be obtained by a combination of uncommon genius with industrious zeal.

His first great labor was assisting Bessel in his survey of the heavens by zone observations from 15° south to 45° north declination, in which the whole of the microscope-readings of the circle were made by Argelander, and there is abundant evidence in Bessel's writings how highly he appreciated the care and skill with which this assistance was rendered, as well as that in the subsequent reductions. These zone observations commenced in August, 1821; earlier in that year Argelander was engaged in observations of stars at low altitude to be used in the formation of Bessel's refraction tables, and also in February and March in the observation of the Comet of 1821.

On the 1st of April, 1822, Argelander took his degree as Doctor of Philosophy, after writing a paper, *De Observationibus Astronomicis a Flamsteedio institutis.* Later in the same year

he published his able treatise, *Investigations on the Orbit of the Great Comet of* 1811, which made his name known through Europe. No other comet had been observed so extensively and over so long an interval of time; and after the most skillful and elaborate treatment of the observations, Argelander obtained an orbit of the period of 3,065·6 years (to be reduced in the next period to 2,888 years). His investigations were not without their influence upon Bessel's views on the repulsive force of comets' tails, which were further developed by him afterward in his labors on Halley's Comet and in his controversy with Encke on the resisting medium in space.

On the death of Walbeck, the position of "Observator" at the Observatory at Abo became vacant, and application was made to Bessel to recommend to the authorities at St. Petersburg one of his pupils to supply it. Though exceedingly unwilling to lose him, Bessel named Argelander, and on April 28, 1823, the latter was appointed to the vacant office, and he left Königsberg in the following month, being succeeded there by Rosenberger. His journey to Finland was also his wedding trip, he having married at Königsberg, on the 2d of May, Marie Sophie Charlotte Courtan; and with her he proceeded, through Dorpat (where he renewed his friendship, commenced in November, 1820, with W. Struve) and St. Petersburg, to his new home in the country of his paternal ancestors.

The Observatory at Abo was then newly built and indeed not in all parts quite completed. Its equipments consisted, besides smaller instruments and clocks, of a 2-foot repetition-circle, a Fraunhofer's heliometer, and especially of a very good 8-foot transit instrument by the same artist. A meridian-circle by Ertel was provided in 1825 and was not ready for use until the spring of 1827. Before that time, therefore, the observations principally consisted of comets, and casual phenomena of different kinds. When in possession of the meridian-circle, Argelander undertook a more extended course of observations; and paid special attention in particular to the stars which were known or suspected to have a large proper motion.

In the year 1828 and 1829 Argelander completed Hour XXII of the Berlin Academy Star-charts, which he had undertaken. It is one of the best of the series, and the accompanying catalogue forms one of the earliest examples of the accurate critical treatment of Bessel's and Lalande's zone observations. In the meantime great changes had occurred at Abo. On the 4th of September, 1827 a fire broke out which laid the greatest part of the town in ashes, and destroyed all the buildings, library, &c. of the University. Although the Observatory was protected by its isolated position, and lost nothing but a large

number of its impressions of printed observations, yet it was ultimately resolved to remove it as well as the University to the new capital at Helsingfors. Argelander was named Professor of Astronomy at the newly founded University there, and a new Observatory was ordered to be erected by the architect Engel, who had already built that at Abo. The plan was approved in 1830; but difficulties were found in laying the foundation on account of the nature of the soil. Finland was also visited about this time by the cholera, which travelled over Europe; and Argelander took an opportunity, after leaving Abo, of revisiting his old home in Prussia, and renewing his personal intercourse with Bessel. In August, 1832 he took up his abode at Helsingfors, though the building of the Observatory was not yet finished. Observations commenced there in the following year; and in November, 1834 the meridian-circle was ready for use, the new observatory being also provided with a Munich refracter of 9 ft. focal length and 6½-in. aperture, observations with which commenced in September, 1835.

Argelander devoted himself principally to an extensive series of observations of the brighter circumpolar stars, and to an accurate investigation of his circle, especially of its flexure, by observation of stars and their reflected images. It was whilst at Helsingfors that he printed the Abo observations and catalogue, as well as his well-known treatise on the motion of the solar system deduced from his own observations of 390 stars, with results nearly similar to that formerly obtained by Sir William Herschel.

His stay at Helsingfors was not of long duration. The Prussian Government had resolved in 1836 to establish an astronomical institution at Bonn, on the Rhine. In August of that year the Directorship of the Observatory was offered to Argelander; and early in 1837 he took up his residence in Bonn, and energetically commenced the ordering of the instruments and the preparations for the building of the Observatory. As a temporary *locale* in the meantime for observations, he selected a bastion of an ancient fortress close to the Rhine, where he carried on for some years his astronomical work with such means as he had—latitude determinations, comet observations, &c. He also made excellent use of his involuntary leisure in the formation of his "New Uranometry," or determination of the relative apparent magnitudes of all the stars visible to the naked eye in Central Europe by direct comparison in the sky, as well as in the connected subject of the changes of magnitude of the variable stars. To the latter he continued to give a great deal of attention afterwards, especially in regard to those interesting stars, *Algol* and *S. Cancri.*

Impatient at the slow progress of the Observatory (as he considered it) Argelander had a small temporary building erected, in which he could use (close to his Rhenish bastion) a 5-foot transit instrument by Ertel, of 4 inches aperture. Having provided this with a sector to determine differences of declination, he commenced extending Bessel's zone observations further to the north, from 45° to 80° declination. Thus he made 26,424 observations of very nearly 22,000 stars; which, begun in May, 1841, were essentially completed, with the aid of an assistant, in June, 1843, some gaps being filled up in the subsequent spring.

At last, in the year 1845, the new Observatory was in a position to be used. Its principal instruments were a 3-foot meridian-circle by Pistor, with telescope of 6-foot focal length, and a heliometer by Merz. For some years cometary observations (a large number of which bodies appeared about that time) and observations of the small planets—the long series of discoveries of which had then just commenced—occupied much of the time of the establishment. But in 1849 Argelander began a new series of zone observations of stars, this time going south from Bessel's limit, or from 15° to 31° south declination. Thus, by May, 1852 he had made, in 200 zones, 23,250 observations of more than 17,000 stars. Every precaution was taken by comparison and by observation of known stars to secure the greatest accuracy possible for the results.

But even before the completion of these southern zones, Argelander had formed a plan for a much greater work to extend the knowledge of the starry heavens. Bessel had before conceived the idea of determining the places of all stars down to the ninth magnitude, but had abandoned it for the scheme of the Berlin Academy Star-Charts, which, however, after the lapse of a quarter of a century, were unfinished, and, moreover, they embraced only a limited zone.

Early in 1852, therefore, Argelander resolved to commence that great *Durchmusterung*, or survey of all the stars of the northern hemisphere down to the ninth magnitude, and including a large number somewhat fainter than that, with which his name will be for ever associated. The whole number of stars recorded in these zones, between the north pole and 2° south declination, amounting to 324,198, and this gigantic labor, including the laying down of the charts and publication both of them and of the catalogues occupied Argelander and his assistants until the year 1863. They are too well known to astronomers to make any discussion of them necessary here. In the seventh volume of the *Bonn Observations*, published in 1869, are some interesting investigations into the proper

motions of 250 stars, which Argelander was led into by comparison of observations.

He always kept in view the desirability of obtaining accurate meridional observations of all stars down to the ninth magnitude, whose approximate positions are contained in the *Durchmusterung.* It was necessary, if this could be done, that the labor should be shared by different Observatories, and be prosecuted on a uniform system. Thus would a basis be afforded for a much larger number of accurate determinations and observations of every kind. In the year 1867 Argelander laid his plan before the German Astronomical Society, which was afterwards adopted, with trifling modifications. The Bonn Observatory was to undertake one zone of 10° in breadth of declination; but Argelander, now approaching his seventieth year, entrusted the details of the execution to his assistants, engaging himself in labors of smaller compass, such as investigations of stellar proper motion.

Argelander always took a lively interest in the progress of science generally, and also in the affairs of the University of Bonn, of which he was twice elected Rector. Many of the scientific societies of Europe and America made him one of their corresponding or honorary members, and he was chosen an Associate of our own on the 14th of January, 1831, being also our medallist in the year 1863.

Until the summer of 1874 he had always enjoyed excellent health; but in August of that year he was attacked by a fever of the typhus kind, which visited the neighborhood about that time. In the autumn he rallied, and was able to resume some of his labors. But the appearance of recovery was delusive; his strength failed more and more, and, retaining his interest in science almost to the last, a tranquil death early in the morning of February 17, 1875, terminated a life which had been so useful to astronomy. His wife (with whom he had been affectionately united for nearly fifty-two years), two sons, and one daughter, married to Professor Krüger, survive him.

W. T. L.

ART. XVII.—*On Dinitroparadibrombenzols and their Derivatives;* by PETER TOWNSEND AUSTEN. First Paper.

Two kilograms of pure crystallized solid (para) dibrombenzol were divided into portions of 250 grams, and each portion added to a mixture of 800 grams of fuming nitric acid and an equal volume of concentrated sulphuric acid, and then heated on a sand bath, when a violent action set in, during which it was found advisable to remove the burners. A red-

dish-yellow oil settled in the bottom of the flask. After boiling three hours the mixture was allowed to cool, and then poured in a thin stream into a large excess of cold water. The oil sank to the bottom and gradually solidified, an operation which may be greatly accelerated by vigorous stirring with a glass rod. The nitrired product from 500 grams of the dibrombenzol after the washing out the acid with water, was dissolved in about a kilogram of glacial acetic acid, filtered, and allowed to stand about seventy hours. A copious separation of the first (α) dinitroparadibrombenzol, containing a considerable amount of the second (β) isomere and but a small amount of the third (γ), took place. By repeated crystallization, first from carbon disulphide and then from glacial acetic acid, it was obtained perfectly pure. The acetic acid filtrate from the first separation contained the β- and γ-isomeres and some of the α. The solution was treated with a large excess of water, and the substances in solution were thus precipitated in the form of a yellow oil, which was then separated from the water by means of a stop-cock-funnel, heated on a water-bath until it was entirely dry, dissolved in about $1\frac{1}{4}$ kilos. of carbon disulphide, and allowed to stand By standing, a small separation of impure α-isomere generally occurs. The carbon disulphide was then distilled off in portions of 200 c. c., and the respective crystallizations, which consisted of the β-isomere containing a good deal of the α-isomere and traces of the γ, collected. When no more separated the thick oil was heated on a water-bath until the carbon disulphide was entirely volatilized, after which it was exposed to a temperature of 5° for three days, when it became solid. The mass was carefully rubbed in a mortar with ether, at the same temperature, and this ethereal extract (consisting of much γ and little β) separated by a filter-pump. The ether was then evaporated, the oil again exposed to the same temperature, and the operation repeated until the substance dissolved in the ether without leaving a residue. The oil was then exposed to a temperature of about $-8°$ to $-10°$, for nearly two weeks, during which small amounts of the β-isomeres crystallized out and were separated by filtering the oil directly with the filter-pump. Finally no more separated from the oil, which then appeared to contain only an exceedingly small amount of the β-isomere.

Alphadinitroparadibrombenzol.

The alphadinitroparadibrombenzol containing traces of the β-isomere crystallizes from glacial acetic acid in beautiful striated transparent needles, often attaining a length of 25 cm. and a diameter of 3 mm. When perfectly pure, however, it crystallizes from the same solvent, in short, compact, white,

glittering needles, or small prisms. From carbon disulphide it separates in the form of small, hard, white crystals. The compound is insoluble in water, easily soluble in boiling absolute alcohol and glacial acetic acid, as well as in benzol, and acetic ether. It is slightly volatile in steam. Fuses at 159° to a transparent slightly yellow liquid.

0·3034 grm. substance gave 0·0190 H^2O and 0·2452 CO^2.
0·1749 grm. substance after the method of Carius gave 0·1998 AgBr and 0·0027 Ag.

Calculated for $C^6H^2(NO^2)^2Br^2$.	Found. I.	Found. II.
C = 22·08	22·04	....
H = 0·61	0·69	....
Br = 49·08	...	49·74

Nitroparadibromaniline.

In a preliminary notice* I mentioned that α dinitroparadibrombenzol by treatment with ammonia formed a dinitrobromaniline, which under the influence of amylnitrite gave a dinitromonobrombenzol. By repetition of the experiments, however, with much larger amounts and perfectly pure substances, I find that the reaction is different.

By treating the α-dinitroparadibrombenzol with strong alcoholic ammonia the crystals take on a light straw yellow color. By heating in a closed tube at 100° for three hours the reaction is completed. The red solution obtained was precipitated with water and the resulting yellow precipitate crystallized from dilute alcohol. The filtrate from the precipitate produced by water gave no trace of bromine with silver nitrate, but starch and potassium iodide proved the presence of a considerable amount of nitrous acid.

By repeated crystallizations from alcohol the substance was obtained pure. It forms orange, yellow, and red needles, which fuse at 75°, and are quite volatile with steam. It is very soluble in most solvents, with the exception of water in which it dissolves with difficulty.

0·28 grm. substance, third crystallization, gave 0·0426 H^2O and 0·2536 CO^2.

0·2092 grm. substance, fifth crystallization, gave, after the method of Carius, 0·2644 grm. AgBr and 0·0008 Ag.

Calculated for $C^6H^2Br^2(NO^2).NH^2$.	Found. I.	Found. II.
C = 24·32	24·69	....
H = 1·01	1·65	....
Br = 54·05	....	54·06

* Ber. d. d. chem. Ges., viii, 1183.

Amyl nitrite acts at ordinary temperatures on the nitroparadibromaniline and forms, not as I formerly supposed, a dinitromonobrombenzol, but the ordinary mononitroparadibrombenzol. All the properties of the nitrodibrombenzol (fusing point 84°) obtained in this manner agreed perfectly with those of the well-known mononitroparadibrombenzol.

This, as far as I know, is the first case in which the nitroxyl of a nitro-haloid-benzol is substituted by the amido-group in preference to the haloid atom. In the first series there is among others the well-known formation of guanidine from nitrochloroform by action of ammonia, effected by Hofmann.*

It seemed extremely improbable that aniline could act in a satisfactory manner on the alphadinitroparadibrombenzol, since the disengaged nitro-group would, without doubt, exert a decomposing influence on the aniline itself as well as on the new compound formed. The dinitrodibrombenzol was treated with an excess of aniline, and the mixture boiled. A strong reaction, attended with a characteristic deep red color, occurred. Chlorhydric acid precipitated an oil, and, by stirring, brown flocks were obtained. The product was soluble in alcohol with a deep red color, but separated from the solution as a slimy mass from which no product susceptible of analysis could be obtained.

By the action of natriumhydrate solution on the alphadinitroparadibrombenzol, I have obtained a substance forming red salts, which I take to be a nitrobromphenol, and concerning which I shall, at the earliest opportunity, give full particulars.

Royal Laboratory of Berlin, April 16th, 1876.

ART. XVIII.—*On a New Formation of Dinitroaniline, and some Reactions of Dinitrobrombenzol;* by PETER TOWNSEND AUSTEN.

ENGAGED in an extensive research concerning the stability of the bromine atom in dinitromonobrombenzol, I was led to treat that compound with potassium cyanate in the hope of obtaining a dinitrophenylcyanic ester, according to the reaction,

$$C^6H^3(NO^2)^2Br + KNCO = C^6H^3(NO^2)^2NCO + KBr.$$

Dinitrobrombenzol was mixed with about one and a half times its volume of potassium cyanate, and the mixture heated to 100° in a closed tube with very dilute alcohol for eight hours; on cooling, the tube became filled with a mass of bright yellow leaflets, and on opening gave off carbonic acid. The

* Ann. Chem. Pharm., cxxxix, 107.

substance, after crystallization from boiling water, fused at 175°–176°, and on analysis* proved to be the ordinary dinitroaniline.

The reaction by which dinitroaniline is formed admits of various explanations. Wöhler has shown that potassium cyanate by repeated distillation with water, splits according to the formula—

$$2KNCO+4H^2O=CO^3(NH^4)^2+CO^3K^2.$$

Hence we may suppose the formation of the dinitroaniline to be due simply to the action of the dinitrobrombenzol on the ammonium carbonate,

$$CO^3(NH^4)^2+2C^6H^3(NO^2)^2Br=2C^6H^3(NO^2)^2NH^2+CO^2+H^2O+2HBr.$$

The bromhydric acid thus formed acts on the potassium carbonate, so that the whole reaction is—

$$2CONK+2C^6H^3(NO^2)^2Br+4H^2O=2C^6H^3(NO^2)^2NH^2+2CO^2+2KBr+2H^2O.$$

We can, however, suppose the action to take place directly without admitting the previous formation of ammonium carbonate—

$$C^6H^3(NO^2)^2Br+KNCO+H^2O=C^6H^3(NO^2)^2NH^2+KBr+CO^2.$$

Nor is there anything very improbable in the supposition that ammonium carbonate is not formed previously, as there are so many cases in which a substance withdraws from another elements not previously directly united with each other, but with which it can form a compound (predisposing affinity).

It is, however, also not impossible that the formation of the dinitroaniline may depend upon the production and subsequent decomposition of a dinitrophenylcyanic ester according to the reaction discovered by Wurtz,

$$\begin{array}{r|l|} C^6H^3(NO^2)^2N & \overline{CO} \\ H^2 & O \\ \hline \end{array}$$

but this appears to me doubtful, since the dinitrobrombenzol is not freely soluble in the very dilute alcohol used. Hence the potassium cyanate is exposed principally to the action of the water, and much less to the action of the dinitrobrombenzol; therefore, although a partial formation of the ester might take place, the chief part of the potassium cyanate would be decomposed at the same time by the action of the water, so that if the ester were formed, it could only be in small quantities.

* Calculated.	Found.
C = 39·34	39·35
H = 2·72	3·01

Mononitrobrombenzol and Potassium Cyanate.

The substances, heated in a sealed tube to 100° with dilute alcohol for eight hours, gave no mononitroaniline, as was to be expected, since mononitrobrombenzol is not acted on by ammonia itself under 160°. The cyanate, however, was completely converted into the corresponding carbonates.

Trinitrochlorbenzol and Potassium Cyanate.

By boiling a concentrated solution of potassium cyanate with trinitrochlorbenzol, I obtained, with strong evolution of ammonia, a red oil which solidified on cooling, and contained considerable unchanged trinitrochlorbenzol. The filtrate contained chlorine (showing that a reaction had taken place), and some picric acid, while chlorhydric acid precipitated a green powder. I have not as yet had time to examine either of these substances farther than to establish the absence of trinitroaniline. By heating for five hours at 100° no picramide was obtained.

Dinitrobrombenzol and Water.

Gottlieb* has stated that trinitrochlorbenzol was decomposed in the cold by water. It was afterwards found by Clemm† that this was not the case, trinitrochlorbenzol not being acted on by water even when boiling. Later, however, Engelhardt and Latschinoff‡ found it was acted on by boiling water.

With dinitrobrombenzol I found no action on boiling with water. The substance was then heated with water in closed tubes successively at 100°, 150°, and 200°, for eight hours, in all these tubes there was no pressure or formation of bromhydric acid. At 220° a minute trace of bromhydric acid had formed, and the liquid was perceptibly reddened on addition of sodium hydrate solution. After heating at this temperature the substance remained liquid for several days, although when it had solidified, it was found to have lost none of its characteristic properties.

Dinitrobrombenzol and Potassium Nitrite.

It appeared not impossible from the ease with which the bromine atom in dinitrobrombenzol can be substituted (although this is chiefly the case in substitution by a positive radical), that by action of potassium nitrite a trinitrobenzol might be formed. The substances were heated in a closed tube six hours with dilute alcohol at 100°. The tube on cooling contained massive red needles of potassium dinitrophenylate. Much aldehyde had also formed. The reaction had probably been—

* Ann. Chem. Pharm., xcii, 326. † Journ. fr. pr. Chem., [2], i, 145.
‡ Zeit. Chem., 1870, 235.

$$C^6H^3(NO^2)^2Br+2KNO^2=C^6H^3(NO^2)^2OK+KBr+(N^2O^3\ ?)$$

The resulting nitrogen oxide, or oxides, had acted on the alcohol and produced aldehyde. Sealed under the same conditions with 99 per cent alcohol, there was but an exceedingly slight reaction, only traces of the phenol having been formed, which doubtless owed their origin to the small amount of water present. The same results were obtained with sodium nitrite. I shall describe the application of this method of phenol formation to other compounds at another opportunity.

Dinitrobrombenzol, Benzol, and Zinc.

Since benzylchloride treated with benzol and zinc dust gives a benzylbenzol, it seemed not improbable that dinitrobrombenzol might give a dinitrodiphenyl, owing to the weakened attraction of the bromine atom from the presence of the nitro-group, although in this case the bromine atom is attached directly to the benzol skeleton, and not indirectly, as in the benzylchloride.

Dinitrobrombenzol, benzol, and zinc dust were heated twelve hours in a closed tube at 100°, and then again at 160°. In both cases there was no action. Toluol instead of benzol also remained unchanged. Perhaps nitro toluol, in which the hydrogen atom of the methyl-group may be weakened by the introduction of the nitro-group in the benzol kernel, may give better results.

Dinitrobrombenzol and Sodium Acetate.

Wishing to ascertain if a dinitrophenyl acetic ester could be obtained according the reaction

$$C^6H^3(NO^2)^2Br,+CH^3COONa=CH^3COOC^6H^3(NO^2)^2+NaBr,$$

I heated the substances with alcohol for six hours in a closed tube at 100°. There was no pressure on opening the tube, but a strong smell of acetic ether. The tube contained orange-red crystals of sodium dinitrophenylate, and in the solution there was considerable sodium bromide. The reaction had probably gone.

$$\text{I.}\quad \begin{array}{r} C^6H^3(NO^2)^2\,|\boxed{BrNa}|\,O.OC.CH^3 \\ C^2H^5\,|\boxed{OH}| \end{array} = \left\{ \begin{array}{l} C^6H^3(NO^2)^2OH \\ CH^3COOC^2H^5 \\ NaBr. \end{array} \right.$$

$$\text{II.}\quad \begin{array}{r} C^6H^3(NO^2)^2O\,|\boxed{H} \\ CN^3.COO\,\boxed{Na}| \end{array} = \left\{ \begin{array}{l} C^6H^3(NO^2)^2ONa \\ CH^3.COOH. \end{array} \right.$$

$$\text{III.}\quad \begin{array}{r} CH^3.COO\,|\boxed{H}| \\ C^2H^5\,|\boxed{OH}| \end{array} = \left\{ \begin{array}{l} CH^3.COOC^2H^5 \\ H^2O. \end{array} \right.$$

So that the whole reaction would be—

$$C^6H^3(NO^2)^2Br + 2CH^3.COONa + 2C^2H^5OH = C^6H^3(NO^2)^2ONa + NaBr + H^2O + 2CH^3COOC^2H^5.$$

The next time, to avoid the formation of acetic ether, the substances were heated with glacial acetic acid at 160°. The whole product was sodium dinitrophenylate. Hence probably,

$$\begin{array}{l} C^6H^3(NO^2)^2|Br.| \\ |CH^3.COO|Na| \\ |CH^3.CO|ONa| \end{array} = \left\{ \begin{array}{l} C^6H^3(NO^2)^2ONa \\ (C^2H^3O)^2O \\ NaBr, \end{array} \right.$$

although at the time I neglected to prove the formation of the acetic anhydride. The substances heated, under the same conditions with acetic anhydride, remained entirely unchanged.

We see hence that although the stability of the bromine atom is greatly weakened by the introduction of nitro-groups, this weakening is to a great extent only in relation to positive radicals. Thus dinitrobrombenzol reacts easily with ammonia, but with potassium nitrite or sodium acetate there is no analogous reaction. By inversion it naturally follows that in aniline the amido-group must be rendered much more stable by the introduction of nitro-groups. This is shown to be so by the fact that while aniline is most violently acted on by amylnitrite, trinitroaniline remains, under the same treatment, utterly unaffected.

ART. XIX.—*On Southern New England during the melting of the Great Glacier;** by JAMES D. DANA.

APPENDIX: ***On the discharge of the flooded Mill River into the Quinnipiac, and the effects as registered in the drift deposits of the New Haven plain.***

IN my memoir on "Southern New England during the melting of the great Glacier," I reached the conclusion† that, during the Champlain period, or that which opened with the melting of the ice, the southern coast of New England, along Long Island Sound, was submerged below its present level not more than fifteen feet, and perhaps less than ten. It was announced,‡ as a consequence of this fact, that the high terraces of stratified drift about the heads of the estuaries and along the river valleys could not have been made by salt water, and must have been due to the freshwaters of the enormously

* The former parts of this memoir are contained in this Journal, III, x, 168, 280, 353, 409, 497, and xi, 178.

† Ibid., x, 434.

‡ Ibid., x, 435.

flooded streams; and that all the drift-deposits of the New Haven region, now thirty to fifty feet above mean tide, were included in the freshwater formations—the saltwater beds being confined to the coast.

The New Haven deposits had been described* as having, to a great extent, a cross-laminated structure, with the oblique lamination dipping for the most part seaward; and hence it was evident—contrary to what I had once supposed—that this dip corresponded in direction with the flow, both being seaward. My former conclusion on this point was based on the view that the New Haven estuary beds were marine in origin; and this appeared to be sustained by the fact† that in the stratified drift beds at the mouth of the Quinnipiac Valley (or where the valley expands into the New Haven plain, west of C on the map, p. 415 of vol. x), the *upper* stratum, twenty feet thick, had the cross-lamination dipping landward, and the *underlying* stratum seaward; for the change of current indicated by this local change of dip seemed to be accounted for by supposing the lower stratum to have been made by the incoming tide, and the upper by the outflowing stream when the flood was at its height. I closed my memoir by rejecting this explanation of the change of current, but without offering any other in its place.

My object at this time is to give another explanation; and to show that while the Quinnipiac waters deposited the lower stratum, the upper was formed by a discharge of Mill River into the Quinnipiac over the place where the unlike strata occur.

As has been explained (and is illustrated on the map, page 415 of volume x), Mill River and the Quinnipiac are parallel streams, joining their waters at the head of New Haven Bay. For the last nine miles of their courses they are less than three miles apart; and the low dividing ridge (Quinnipiac Ridge of the map) terminates near New Haven in the short trap and sandstone ridge called East Rock (E, on the map). Below this termination no barrier intervenes excepting a plain of drift deposits, and here is the place where the upper stratum of twenty feet has the reversed cross-bedding. Now if it can be shown that Mill River was throughout its course a violent cataract, flowing at a level far above that of the Quinnipiac, while the Quinnipiac for the last six miles had almost no descent, and was in this part more like a lake or basin than a river, it will be plain that Mill River, on clearing the south extremity of the East Rock ridge, would have rushed around the point, toward the Quinnipiac.

The facts sustaining this view have already been stated in

* Ibid., x, 191. † Ibid., x, 173.

my former papers.* At North Haven, or six miles north of New Haven, the Quinnipiac River is now on a level with the ocean, while Mill River in the same latitude is sixty feet above it. The valley-terrace of stratified drift is, in each valley, about forty-five feet in height above the stream. Consequently, in the Champlain period the descent, from that point to Long Island Sound, of Mill River was 105 feet, and of the Quinnipiac, only forty-five feet. Moreover, the Quinnipiac terrace has nearly the same height at North Haven and five miles south; so that the waters over this broad area during the Champlain flood were nearly those of a great basin. But, abreast of this long Quinnipiac basin, the Mill River torrent was dashing on with a pitch of ten feet a mile. And it continued this rapid plunging course along its shallow valley until it had passed East Rock, where the valley terrace is seven feet higher than that of the Quinnipiac adjoining. It is therefore manifest that, on reaching the southern extremity of the ridge separating the two valleys, it would have made a quick turn around the promontory and plunged into the Quinnipiac basin; and this would have carried it northeastward directly over the place where the evidences of reversed currents occur in the drift deposits. This place of discharge would not have taken off all the Mill River waters, or the larger part; for the water level there, when the flood was at its height, was still thirty to thirty-five feet above the sea-level—height enough to have kept the tumultuous waters mainly on a seaward course.

We hence learn from the drift deposits at this place of junction of the two streams, southeast of East Rock, (a mile north of the present head of New Haven Bay and six miles from its eastern cape), the following facts:

1. Until the waters of the flooded streams had reached, at the place mentioned, a height of fifteen feet above the then-existing sea-level, neither stream overbalanced the other; for the deposits of the lower stratum within the range of the Quinnipiac valley show, by their structure, that they were made by the flow of Quinnipiac waters. The pitch of the waters to the Sound was then but two or two and a half feet a mile.

2. Until the same water-level was reached, the flow—though rapid and plunging, as proved by the flow-and-plunge structure of the beds—was quiet compared with what followed; for this lower stratum consists mainly of sand and fine pebbles.

3. The increase in the flood on passing that level was sudden, as if the dissolution of the glacier had then received greatly accelerated progress. For the transition in the bedding, and in the color of the sands, is abrupt, with no fine layer between to indicate an epoch of repose; and, moreover, the *upper* stratum is

* Ibid., x, 413.

very much the coarsest; along Mill River valley, it is to a great extent, in contrast with the stratum it overlies, a cobble stone deposit, and this evidence of hurrying waters continues along its course through the New Haven plain for a mile and a half to the Bay.* Further, the height of the deposits where the stones are coarsest is ten feet below the normal height, because in the dashing flood, the finer material was drifted off.

4. The flow from Mill River into the Quinnipiac basin diminished in velocity as the waters spread in that direction. For, while the upper stratum adjoining Mill River on the east is a mass of coarse pebbles, too stony to show any cross-bedding, going farther eastward, toward the Quinnipiac, the stony character diminishes, and finally, in the course of three-fourths of a mile, the beds consist largely of sand.

5. The great plain of stratified drift, southeast of East Rock, forty to forty-three feet in height above the sea-level, which bounds the Quinnipiac salt meadows on the south and pushes the river against the eastern hills, was made largely of sands contributed by the Mill River torrent.

6. The Quinnipiac waters added little to the height of this drift-deposit plain or terrace: for the upper stratum bears evidence of Mill River action nearly or quite to its top. There are over the top some areas of whitish sand, one to three or four feet thick; and a bank of such sand, finely and evenly bedded, lies, unconformably against the slope of stratified drift facing the Quinnipiac basin; † and these may be formations from the Quinnipiac waters after the Mill River floods had subsided.

7. Mill River—now not over fifteen miles in length—is an example of a little stream that was a great river during the Glacial flood. It owes this partly to its having been one of the water-courses that aided, as I have pointed out,‡ in discharging the flooded Connecticut—the overflow at Northampton and Westfield giving a vast supply of waters to the Farmington Valley, enough to fill the wide valley over a hundred feet in depth, and forcing them to find a discharge into Long Island Sound by the Quinnipiac and Mill Rivers. It was probably through this supply of waters from the Connecticut that the floods of Mill River were prolonged until the drift deposits of the New Haven plain had reached their extreme height.

* Ibid., x, 175.

† Ibid., x, 179, 180, where a figure is given. The origin of these beds is otherwise explained at that place, the error that the estuary beds were marine, coloring much of the reasoning in that first paper on "Southern New England."

‡ Ibid., x, 506.

ART. XX.—*The Greenstones of New Hampshire and their organic remains;* by GEO. W. HAWES. With plate V.

THE occurrence in Eastern North America of rocks pertaining to what is appropriately styled the "greenstone" series has been noticed by different observers. In a report upon the geology of the Connecticut Valley, Professor Edward Hitchcock distinguished these from all the other rocks, by the name of "chloritic and talcose schists."* Dr. T. Sterry Hunt, in the Geology of Canada, has given analyses and descriptions of greenstones, and has discussed their mode of formation. Professor C. H. Hitchcock has noticed these rocks in New Hampshire, and has carefully studied their extent and distribution.† The "chloritic formation" near New Haven, which was noticed at length by Percival, has been recently determined by Professor J. D. Dana to consist of greenstones, and its relationship to the surrounding formations has been by him pointed out.‡ In the present article it is proposed to describe some of the more important members of this group occurring in New Hampshire, and, from the evidence afforded by chemical and microscopic study, to attempt to show their origin and mode of formation. These studies have been prosecuted under the direction of the Geological Survey of New Hampshire, at the head of which is Professor C. H. Hitchcock, and with his aid it is proposed to prepare a treatise, as complete as possible, upon the rocks of the State, which will form a part of the third volume of his report.

These greenstones, as described by Professor Hitchcock, cover a large area in the northern part of the State, and extend southward over a long irregular strip of territory which follows the course of the Connecticut Valley. They are referred by him to the Huronian age. The rocks of the whole formation are very generally green, and there is a remarkable constancy in their mineral and chemical composition, owing doubtless to the constancy of the conditions under which the beds were originally accumulated. There is sufficient diversity in these rocks, both in physical and chemical properties, to allow the best of evidence to be obtained in the field, showing that they are all metamorphosed sedimentary accumulations, instead of igneous in origin, as too generally claimed for rocks of this class. They are interstratified with one another in various ways, and are far from appearing as a result of violent eruptions,

* This Journal, I, vi, 26.
† This Journal, III, vii, 468 and 557, also vol. i, Geology of New Hampshire, p. 532.
‡ This Journal, III, xi, 119.

they were accumulated in quiet waters and consolidated under very gentle influences.

As in the vicinity of New Haven—where the rocks have been shown to be of undoubted metamorphic origin—many kinds are found which so closely resemble true trap rocks, that it is well nigh impossible to distinguish them in hand specimens; and, as will be seen beyond—there are cases where even the most careful microscopic study is inconclusive. Although only extended observations made in the field can decide whether the rocks are truly stratified or intrusive, yet it is believed that some characters are given in the descriptions beyond which will be of service in their classification.

The old name "greenstone" is a good general term to apply to the whole group, because the prevailing color of the rocks is green; indeed it is so common that the formation has always been colored green upon the geological maps; and the term "greenstone" has now become so wide in its meaning that it may well embrace all the rocks of the formation. It is intended to include under the term, all basic metamorphic rocks whose prominent coloring ingredient is either hornblende, pyroxene or chlorite. There are green acidic rocks in the formation, but they do not sufficiently resemble the rest to need to come under a common term. The true greenstones are all so much alike in physical appearance, that if the term is restricted as proposed it will be found of much convenience in use.

In this formation there are many varieties of all the rocks spoken of in this article. It is proposed here to describe these variations in but general terms, but in the third volume of the Geology of New Hampshire, the rocks will be more minutely described, additional figures will be given, together with the results of the study of the other rocks found with these, but which are not greenstones if we restrict that term as proposed.

1. *Metamorphic Dioryte.*—The most prominent member of this group of greenstones is metamorphic dioryte, or *metadioryte*, and it includes both oligoclase-dioryte and labradorite-dioryte; varieties which in the region cannot be distinguished without a chemical analysis. This rock is very variable in its texture in different localities, sometimes being so coarse as to enable one to separate the crystals mechanically, and observe the cleavages of the minerals; sometimes being very compact, and well nigh impossible to distinguish from doleryte. The hornblende gives a dark color to the rock, and by this property it is easily distinguished from the light green chloritic rocks. The feldspar is not easy to determine; but an examination of its optical properties shows it to be triclinic. Whether it be oligoclase or labradorite is not a matter of great importance, since a very slight variation in the composition of the sediments would produce a change in the species.

The microscope furnishes as conclusive proof as the stratigraphy that these diorytes are metamorphic. Often in these basic rocks free quartz is associated with feldspars low in silica; and in Stewartstown there is a dioryte in which carbonate of lime is associated with a triclinic feldspar, and also free quartz. Such circumstances as these are easily understood, if these rocks were consolidated under very gentle metamorphic influences, but would not be expected in a rock which had been once in a condition of igneous fusion except as a result of alteration. It seems as if the mass had been under such conditions of heat and pressure as to give action to chemical affinities, but only within a very narrow range; so that crystals of different minerals might be formed from *fine* mud, while a larger grain of sand would be left unaffected. The conditions of metamorphism were such that they gave full scope to chemical affinity, only where the original deposits were impalpable in texture.

These diorytes vary much in their mineral composition. At Littleton some are very feldspathic, with large crystals of labradorite, making a porphyritic dioryte. At North Lisbon some specimens are very hornblendic, and large crystals of hornblende are developed in the finer ground-mass. At Lancaster they are very micaceous, and there are everywhere coarse-grained and fine-grained varieties. Fig. 1, plate IV. is intended to illustrate the appearance of the minerals of these diorytes under the microscope with ordinary transmitted light. It is drawn from a thin section of the North Lisbon rock, and is magnified 35 diameters. It shows the color of the hornblende, which, while dark in the mass, is very prettily green when made so thin. The hornblende is generally fibrous, and is found in large crystals, yet microscopic crystals are always scattered through the feldspar, as shown. The mica is biotite and very dichroic, becoming nearly black with a quarter revolution of one nicol. A round grain of quartz is seen in the middle of the feldspar, and the feldspar when placed between the nicol prisms is found to be triclinic.

To the chemical variations reference has already been made. To serve as a basis for calculation, the hornblende contained in a dioryte from North Lisbon was analyzed. In it the hornblende in places had crystallized out in large orbicular masses half an inch in diameter. It appears under the microscope in color and structure like the large crystal in the section figured. The crystals are fringed on the edges, and consequently on the outside are intimately mixed with feldspar; but in the middle they are pure, as was proved with the microscope. A portion of the hornblende free from associated ingredients was analyzed with the following results:

Silica	49·03
Alumina	13·72
Ferrous oxide	9·84
Manganous oxide	·40
Lime	11·22
Magnesia	11·96
Soda	2·40
Water (ignition)	·90
	99·47

This analysis shows that these diorytes have a highly aluminous hornblende, resembling in all respects some kinds of the variety called pargasite. I would refer to the analyses published upon page 238 of the fifth edition of Dana's Mineralogy. That hornblende can thus take into its composition so much alumina and alkali shows under what varying conditions of composition this mineral may be formed. An analysis of the rock from North Lisbon gave 51·25 per cent of silica, while another containing the same variety of hornblende gave 55·62 per cent. In the former the feldspar is labradorite, and the amount of silica in the latter seems to imply that it is probably part or all oligoclase.

In some places the dioryte develops a well defined schistose structure, and thus becomes *diorytic schist.* The microscope is unable to detect a great difference in composition; it only indicates a more finely fibrous and more diffused hornblende, less feldspar, and more grains of quartz. This rock is very common at Cornish. By further addition of quartz and diminution of the feldspar this rock graduates into hornblende schist.

2. *Metamorphic Diabase.*—Hydrous rocks are very common in this region, in which chlorite is a prominent ingredient. They generally contain pyroxene and sometimes hornblende. These rocks like the hornblendic are both massive and schistose. The massive rocks, having labradorite in addition to the minerals above enumerated, are *metadiabase.* They are very extensively developed in the extreme north, but are common as far south as Hanover. They are often quite complex in structure, but, as in the case of igneous diabase,* the chlorite imparts to the rock a light green color which makes it easily distinguishable from the diorytes. In plate V, figure 2. the microscopic structure of this rock is represented. The figure is drawn from a section of a specimen from Littleton, and is magnified 35 diameters. The chlorite in these rocks has usually an amorphous appearance, occurring, as shown in the figure, in irregular masses, with little appearance of structure; yet, as it exhibits bright colors between crossed nicols, it is all

* This Journal, vol. ix, March, 1875.

crystalline. The pyroxene shows the characteristic cleavage, as indicated in the figure and also exhibits bright colors between the nicols, such as are seen in the pyroxene of figure 4. The feldspar looks impure and is filled with rifts and with numerous particles of chlorite and amorphous matter yet shows its characteristic bands of color between the nicol prisms. Hornblende sometimes replaces the pyroxene in these rocks, and is often present with it. The occurrence of these two minerals in the same rock is interesting, and the following analyses throw some light upon it. The first one is of a wholly chloritic kind, from Littleton; while the latter, from Pittsburg, is of a variety containing hornblende. The specific gravity of each is 2·96.

	Littleton.	Pittsburg.
Silica	45·56	48·79
Alumina	16·57	16·97
Ferric oxide	·36	1·69
Ferrous oxide	9·40	8·97
Manganous oxide	·20	·20
Lime	8·01	9·98
Magnesia	10·34	6·98
Potash	1·20	
Soda	2·55	3·30
Titanic acid	1·20	1·10
Water	3·93	2·65
Carbonic acid	1·02	
	100·34	100·63

On comparing these two analyses, little difference is seen between them, or between them and the corresponding igneous rocks. It will only be noticed that the one which is the more chloritic contains, naturally, more water and magnesia and less silica; hence, if in the rock represented by the second analysis the same chlorite was formed, and its amount was limited by the amount of water, there would be left a residue (corresponding to the remainder of chlorite in the first rock), which would make an aluminous hornblende; for there is little difference between the hornblende of which an analysis is given on page 132, and some chlorites save in the greater percentage of silica, and smaller of water, for the lime and magnesia are capable of replacement in either the hornblende or pyroxene. The conditions for the formation of both hornblende and pyroxene in a rock will be made a subject of further study. It seems to me to be dependent upon a low grade of metamorphism at a temperature below that which would have converted all into pyroxene and above that which would have determined it all to be hornblende. In view of the fact that the hornblende of

these rocks contains so large a proportion of alumina and also alkali, it will be seen how many combinations could be made from the same material. They both contain about two per cent of titanic iron and the oxygen ratio of the whole makes it probable that the feldspar is labradorite. There is present also some pyrite, and apatite or some mineral phosphate. For analysis, portions of the rock free from pyrites were selected; the phosphoric acid was not determined, but it was found to be present when a careful test was made, and the microscope reveals some minute crystals which appear like apatite.

3. *Organic remains in the metadiabase.*—In the microscopic study of these massive chloritic rocks, or metadiabase, I have found certain forms which appear to be of organic origin. Two of them are figured on plate V, in figs. 5 and 6.

Figure 5 represents a specimen from the metadiabase of Connecticut lake in Pittsburg. It has the structure of a tabulated coral, resembling much a *Chætetes*;* but on account of its minuteness, in connection with other characters, there is little question but that it is a fragment of a rhizopod mass or foraminifer; and a close resemblance to a *Stromapora* will be noticed. The figure, like all the others, is drawn from a thin section of the rock, magnified thirty-five diameters. The breadth of the cells is hence but $\frac{1}{280}$ of an inch. These forms seem to be abundant in the rock; for, in a section of a fragment of rock half an inch square in surface, several bits of the fossil are sometimes found. The specimen figured is the most perfect that I have seen; but smaller fragments are abundant, and as they are apparently alike in dimensions, they sustain the supposition of the organic origin of all.

In the metadiabase of Hanover another form was found, which is represented in figure 6. This is very likely a section of a fragment of the same species of rhizopod cut in a different direction.

These forms, distributed through the massive rock, have a structure, as the figures show, which cannot be attributed to crystallization. They seem to make it evident that rhizopods must have been living over the sea bottom during the accumulation of these sediments, and became buried in the mud which is now the material of the rock. These forms are composed of silicates, but of what precise kind it is difficult to determine, since the particles are minute and their optical properties are obscure. Yet upon placing a drop of acid upon one of them it effervesced for a short time, showing that carbonate of lime existed in it—perhaps part of that of the original foraminifer.

The presence of these remains of rhizopods in the metadia-

* It also calls to mind the series of cells of a Bryozoan. See figures of *Lichenalia concentrica*, Plates 37 A and 40 E, Natural History of New York, Part VI, Palæontology, Vol. 2, by James Hall.

base is additional evidence of the sedimentary origin of these rocks; and they also confirm the view that the metamorphism was feeble in its degree, since it allowed of the preservation of these forms. It suggests, moreover, a source for the lime of the labradorite and other minerals of the rock, as well as for its pyrite and phosphate. Associated with these rocks are extensive beds of argillytes, which are scarcely altered. Everything points to quiet waters during the original deposition; and finally to gentle metamorphism.

4. *Chlorite Schist. Metadiabase Schist.*—Metadiabase, by the development of a schistose structure, becomes metadiabase schist; or, as it is commonly called, chlorite schist. This rock is very abundant everywhere in the formation. It is schistose, but the laminæ are often so firmly united that its structure is manifested only on fracture. It is distinguished from hornblende schist by its light green color, and by giving off water when heated. Under the microscope the chlorite is crystalline and strongly dichroic. Its crystals are mostly in the plane of lamination, and the pyroxene is in minute particles. A specimen from Hanover, having a gravity of 3·03, was analyzed, by Mr. Pease of the Sheffield laboratory, with the following result:

Silica	46·55
Alumina	19·26
Ferric oxide	2·58
Ferrous oxide	9·73
Manganous oxide	·25
Lime	9·07
Magnesia	6·67
Potash	·09
Soda	3·31
Titanic acid	·52
Water	2·39
	100·42

This rock which, as the microscope shows, contains but little titanic iron, yet has more than twelve per cent of oxides of iron; and hence the analysis indicates a ferruginous chlorite containing but little magnesia. The chlorite which best fulfills the conditions of composition and optical properties is the one which occurs in igneous diabase—the diabantite;* and which is very apt to be formed in ferruginous rocks. If we consider the water as an index to the amount of this chlorite, and the remaining magnesia to indicate pyroxene, we find that the rock consists of 25 per cent of chlorite, 20 per cent of pyroxene, 1 per cent of titanic iron, and a residue nearly identical in composition with labradorite. These schists are sometimes highly

* This Journal, vol. ix, June, 1875.

porphyritic, and sometimes large crystals of feldspar are sparsely scattered through the mass.

Some of the metadiabase schist resembles closely specimens of the German *schalstein*, which like these is often associated with massive diabase, but which is considered to be the consolidated tuff that has resulted from the wear and tear of the massive igneous rock. The New Hampshire rock, as all the facts show, is unquestionably a result of the metamorphism of sediments, like the others of the greenstone series. These stratified kinds give us the plainest conceptions of the mode of origin of the whole.

5. *Metamorphic Doleryte.*—There is one more massive rock to which I refer on account of its lithological interest. It is the compound of pyroxene, triclinic feldspar and titanic iron, which is found at Littleton. The rock has the composition of a doleryte. Yet it contains diallage, or foliated pyroxene in large individuals, and hence it would be generally called gabbro. As the crystalline condition of the pyroxene seems to be an unimportant distinction, I here refer it to *metadoleryte*. The color of this rock is quite dark gray, and large orbicular crystalline masses of diallage are developed in a finely granular base. Its composition is as follows:

Silica	40·25
Alumina	13·62
Ferric oxide	5·46
Ferrous oxide	10·36
Lime	10·31
Magnesia	8·86
Potash	·59
Soda	1·96
Titanic acid	6·53
Water (ignition)	·74
	98·68

The microscopic structure of this beautiful rock is illustrated in figures 3 and 4 of Plate V. Fig. 3 represents the appearance of a thin section magnified thirty-five diameters, by ordinary transmitted light, while fig. 4 represents the appearance of the same between crossed nicol prisms. It contains as the figure and analysis show, a large amount of titanic iron, and hence the low percentage of the silica. Fig. 4, which illustrates the effect of polarized light shows the banding of the feldspar, which is either labradorite or anorthite. But the thing of most interest is the association of hornblende with the pyroxene. It is quite evident from a study of the section that the colored mineral was originally all pyroxene, and that it has now been partly changed into hornblende. That the horn-

blende resulted from the pyroxene is shown by the spots of hornblende in the pyroxene; the outline of these altered spots is quite indefinite and indistinct, indicating plainly the fact of change. When change of species takes place with no change whatever of chemical composition, it does not follow that the alteration should begin at the outside as in other cases, and as here seen this change began at the middle. Other crystals are seen to have so completely changed as to develop beautifully the cleavage of hornblende, while at the same time a good illustration of the cleavage of pyroxene is seen in the same slide. This alteration, which is not uncommon in other regions, is of much importance in New Hampshire, for in nearly all the trap rocks, the same change has taken place. It will be noticed that the pyroxene changes into a yellowish-brown strongly dichroic hornblende, and not into the bright green one which characterizes the original diorytes.

6. *Argillyte.*—In closing, I give an analysis of one of the non-crystalline rocks which abound in the region, in support of some of the views that have been advanced. The one that I select is from Woodville, and is a corrugated argillyte. The composition obtained is as follows:

Silica	60·49
Alumina	19·35
Ferric oxide	·48
Ferrous oxide	5·98
Lime	1·08
Magnesia	2·89
Potash	3·44
Soda	2·55
Water	3·66
	99·92

In this rock the microscope shows only incipient crystallization; yet it has a composition that would have made a good granite if circumstances had favored; but owing to the feeble degree of the metamorphism, the sediments of this composition were well nigh unaffected. The reason for this is seen in its small percentages of lime, magnesia and iron.

In conclusion, it appears from the facts described, that the greenstones of New Hampshire have been formed from fine sedimentary deposits which were accumulated in still waters; that the metamorphic action under which they were consolidated was quiet or gentle in degree, far different from that which in the adjoining regions has formed mountain masses of granite and gneiss, and hence that their special location in the region of metamorphic action, in connection with the nature of the sediments, has determined the characters of the greenstone series.

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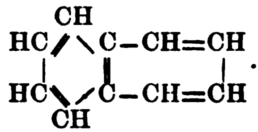
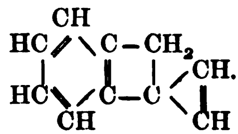
SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

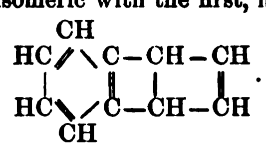
1. *On the constitution of Naphthalene.*—The constitution of the hydrocarbon naphthalene has been fixed, from its close analogy with benzene, as follows:—



Wreden has recently proposed two other formulas for this substance and has given his reasons for preferring them. These rational formulas are both unsymmetrical. The first is the most important, and is:—



The arguments offered are: 1st, the important pyrogenesis of naphthalene observed by Berthelot from styrene and ethylene, showing that the latter grouping is present. 2d, the decompositions of its molecule by oxidation and reduction. 3d, the mutual formation of decahydronaphthalene and hexahydrocymene by the reduction of naphthalene. 4th, the four possible monosubstitution derivatives indicated by the above formula, three of which have already been obtained. 5th, the formation of unsubstituted phthalic acid from dichlornaphthoquinone and of tetrachlorphthalic acid from pentachlornaphthalene is no evidence for the correctness of the symmetrical formula. 6th, the existence of two perchloronaphthalenes. And 7th, the existence of two analogous compounds, isomeric with styrene and acetenylbenzene, which this theory foresees may be synthesized from benzene and ethylene. The second formula, isomeric with the first, is:—



It differs from the symmetrical formula only in the mode of combination of the carbon atoms. Arguments 1, 4, 5, 6, and 7 apply also to it.—*Ber. Berl. Chem. Ges.*, ix, 590, May, 1876. G. F. B.

2. *Conversion of normal into iso-butyric acid.*—Erlenmeyer has observed a remarkable conversion of normal into isobutyric acid. In order to show the curious inversion of solubility in hot and cold water of calcium normal butyrate and isobutyrate, he

sealed up in glass tubes a cold saturated solution of the former and a hot saturated solution of the latter. This last tube on cooling deposited crystals while the first tube did the same on heating. After repeating the experiment for class instruction many times, the quantity of the normal butyrate crystals appeared to lessen on heating, and on strong cooling crystals appeared resembling the isobutyrate. This result careful examination confirmed. Since boiling for eight days did not effect the change, time must be the requisite.—*Liebig's Ann.*, clxxxi, 126, May, 1876. G. F. B.

3. *On the Influence of Asparagin on Saccharimetry.*—CHAMPION and PELLET have studied the influence exerted by the rotatory power of asparagin upon the indications of the saccharimeter. Its aqueous solution (containing when saturated 1·66 to 1·72 per cent) rotates the yellow ray $-6° 14'$; after adding ten per cent of ammonia $-10° 41'$. For white light the rotation $-11° 23'$ was obtained, corresponding closely with that of M. Bouchardat, $-11° 18'$. On adding a mineral acid, the sign changes. An aqueous solution of asparagin containing 10 per cent of hydrochloric acid, has a rotatory power of $+37° 27'$ for the yellow ray. Now since Dubrimfaut has shown that beet roots contain 2 or 3 per cent of this substance, the indications of the saccharimeter are somewhat too high, since the juice, although alkaline after clarification with basic lead acetate, still has a plus rotatory power. This error may amount to 0·7 gram of sugar in the 100 c.c. The authors find, however, that the rotatory power of the asparagin is entirely destroyed by the addition of acetic acid. They recommend the addition to the solution, after treatment with the basic acetate, of 10 c. c. of acetic acid (at 8°) to every 100 c. c. The same fact to a less degree is true of the juice of the cane. The authors propose the titer before and after the addition of the acid, as a method for estimating asparagin.—*C. R.*, lxxxii, 819, April, 1876. G. F. B.

4. *On the Alkaloid Aricine and some related Bodies.*—HESSE has subjected to a new and exact investigation the cinchona alkaloid discovered in 1829 by Pelletier and called aricine, obtained from a new bark *Cinchona pelleterana.* He comes to the conclusion that aricine, as well as the cinchovatine of Winckler, and a new lævo-rotatory alkaloid discovered by de Vrij in 1873, are identical in the pure state with cinchonidine. The alkaloid called aricine by Howard, was probably paricine containing cinchonine. —*Liebig's Ann.*, clxxxi, 58, May, 1876. G. F. B.

5. *Analysis of Mixed Liquids.*—DR. SIEMENS has designed an instrument by which a stream of alcohol and water mixed in any proportion, is measured in such a manner that one train of counter wheels records the volume of the mixed liquid; while a second counter gives a true record of the amount of absolute alcohol contained in it. The principle on which this measuring apparatus acts may be shortly described thus: The volume of liquid is passed through a revolving drum, divided into three compartments by radial divisions, and not dissimilar in appearance to an ordinary wet gas-meter; the revolutions of this drum produce a

record of the total volume of passing liquid. The liquid on its way to the measuring drum passes through a receiver containing a float of thin metal filled with proof spirit, which float is partially supported by means of a carefully adjusted spring, and its position determines that of a lever, the angular position of which causes the alcohol counter to rotate more or less for every revolution of the measuring drum. Thus, if water only passes through the apparatus the lever in question stands at its lowest position, when the rotation motion of the drum will not be communicated to the alcohol counter, but in proportion as the lever ascends a greater proportion of the motion of the drum will be communicated to the alcohol counter, and this motion is rendered strictly proportionate to the alcohol contained in the liquid, allowance being made in the instrument for the change of volume due to chemical affinity between the two liquids. Several thousand instruments of this description are employed by the Russian Government in controlling the production of spirits in that empire, whereby a large staff of officials is saved, and a perfectly just and technically unobjectionable method is established for levying the excise dues. —*Nature*, xiv, 58. E. C. P.

6. *Viscosity of Salt-Solutions.*—M. Grotrian has determined the constants of friction of some salt solutions and their relations to galvanic electricity. The oscillations of a suspended disc with attached magnet (under the influence of a neighboring magnet) were observed in air and in the liquid under examination. The observed generally similar curve of temperature coefficients for fluidity and galvanic conductivity, with change of concentration, leads the author to conclude that the overcoming of internal friction forms an essential part of the work done by a current in passage through an electrolyte. In the case of chloride of potassium it is found that the increase of conductivity is almost exactly proportional to the percentage proportion (in the liquid); and Mr. Grotrian infers that the chemical changes he conceives generally to occur in chemical constitution of electrolytic molecules, on altering the concentration, do not occur here, but that with varied concentration, at the same temperature, the conductivity is only conditioned by the proportion of salt and the viscosity. With the numbers obtained in the experiments, it is possible to estimate for variously concentrated solutions of a salt, the temperatures for which the constants of friction have some determinate constant value; then to calculate the numbers for the conductivity at this temperature, and inquire according to what law these alter with the concentration. He thus shows that in the case of NaCl, KaCl, $CaCl_2$, and $BaCl_2$ the concentration and the viscosity are the principal factors, which determine the amount of the conductivity. —*Pogg. Ann.*, clvii; *Nature*, xiv, 142. E. C. P.

7. *Viscosity of Gases.*—Herr von Obermayer has recently communicated a memoir to the Vienna Academy on the relation of the coefficients of internal friction of gases to the temperature. If we accept for the coefficients of friction μ at $t°$ C. the formula

$\mu = \mu_0(1+\alpha t)^n$ while α is the coefficient of expansion of the gas taken as a basis of the calculation, then the experiments of Obermayer give the following values of n:—Air, 0·76; hydrogen, ·70; oxygen, ·80; carbonic oxide, ·74; ethylene, ·96; nitrogen, ·74; protoxide of nitrogen, ·93; carbonic acid, ·94; ethyl chloride, ·98. The coefficient of friction of the permanent gases is, according to these experiments, approximately proportional to the $\frac{3}{4}$ power and that of the coercible gases to the 1-power of the absolute temperature.

For temperatures between 150° and 300° C. air gave the same values of n as between the lower temperatures $-21·5$ and 53·5. In the case of carbonic acid a slow decrease of the exponent n with the temperature was perceptible from the experiments.—*Nature*, xiv, 119. E. C. P.

8. *Simultaneous Sounding of two Notes.*—Dr. R. König sums up the results of an elaborate series of experiments of the effect of two tuning forks sounded together as follows:

I. (1) The number of beats of two notes n, n' is always equal to the positive and negative remainder of the division $\frac{n'}{n}$; that is, equal to the numbers m, m', which are produced by stating $n' = hn + m = (h+1)n - m'$, while n, n' are the number of double vibrations, and h the quotient of the division which gives the remainder m. It is as if the beats proceeded from the two overtones h and $h+1$ of the lower note n, between which the higher note n' lies. The cause of the beat-notes is simply the periodical coincidence of the common maxima of the two sound-waves.

(2) The beats of the pure harmonic intervals can be heard in the relations 1 : 8 and even 1 : 10, and may, as well as the beats of the unison, be regarded as resulting directly from the composition of the vibrations of the primary notes, without the help of resultant intermediate notes, whose existence cannot be proved.

(3) Both the beats m and the beats m', not only of the interval $n : n+m$, but also of the interval $n : hn+m$ ($h=2, 3, 4$), when the intensity of the primary notes and their number are sufficient, change into beat notes.

II. (4) When the two beat-notes m and m' are near the unison, the octave, and the twelfth, the same beats may be heard as would be produced by two equal primary notes. I have named these beats arising from beat-notes secondary beats, in order to distinguish them from the beats arising from primary notes.

(5) When the intensity of the beat-notes by which they are formed and their numbers are sufficient, these secondary beats change to a secondary beat-note, as primary beats change to a primary beat-note.

III. (6) The difference-notes and summation-notes, which are produced by the change of two loud notes (the vibrations of the latter not being infinitesimal), produce a phenomenon which is independent of the beats and beat-notes; they are only much weaker than the beat-notes.

IV. (7) The beat-notes cannot be explained by reason of the difference-notes and summation-notes, because the number of their vibrations is in many cases different from what this cause might produce.

(8) The audibility of the beats depends solely upon their number and upon the intensity of the primary notes, and is independent of the distance of the interval.

(9) The number of the beats and of the primary impulses in which both may be perceived as separate impulses is the same.

(10) With the beats perceived as separate impulses, as with the primary impulses perceived in the same manner, the note which approaches them in number is audible.

(11) The number at which beats and primary impulses can change into one note is the same.

(12) As with beats and primary impulses, the intermissions of a note can also change into one note.

(13) When the vibrations of a note vary periodically in intensity, the periodical maxima of vibration change into one note, if their number is sufficient.

(14) The beat-note which is formed by two primary notes must always be weaker than the latter, although single beats are stronger than the notes which form them.—*Phil. Mag.*, l, 417, 511. E. C. P.

II. Geology and Mineralogy.

1. *Critical Observations on Theories of the Earth's physical evolution;* by Capt. C. E. Dutton. (The Penn Monthly, May and June, 1876.).—Captain Dutton presents in this paper the views brought out in his article in volume viii of this Journal, with fuller illustrations, and adds explanations of his theory of the origin of mountains. The discussion should be read by all desiring to reach right conclusions, it presenting many arguments from physical considerations against the contraction-theory, or that of the uplifting and folding of strata through lateral pressure. There is much to be learned before any theory of mountain-making shall have a sufficient foundation in observed facts to demand full confidence, and Captain Dutton merits the thanks of geologists for the aid he has given them toward reaching right conclusions. His discussions are not free from misunderstandings of geological facts, and if they fail to be finally received it will be for this reason. The subject is too large a one for a full statement, in a book-notice, of the apparent difficulties and sources of doubt which might occur to an advocate of the latter theory.

We here give in a brief form, and nearly in his own words, the principal points in his theory of mountain-making as explained in the later part of his memoir.

Accepting the proposition that there is a plastic condition of rock beneath the earth's crust and that metamorphism is a "hydrothermal process," and believing that "the penetration of water to

profound depths [in the earth's crust] is a well sustained theory," he says that great pressure and a temperature approaching redness are essential conditions to metamorphism; that the state of silica, alumina, etc., in the process, is like that when these oxides are obtained in the soluble hydrous condition, and therefore they would have had less specific gravity than they have in the crystalline anhydrous condition; and that a diminution of heat or pressure would have been followed by crystallization and an increase of density; that the deeply buried rocks would require but little expansion to cause a diminution of specific gravity; and, if they become highly plastic from any cause, then the position of the superior or overlying strata would be one of unstable equilibrium; if heated without becoming plastic, or if plastic and yet denser than the overlying beds, the expansion would cause a vertical upward movement and attendant results, including in some cases great fractures owing to inequalities in bedding and texture and the consequent unstable equilibrium; that the axes of maximum deposit would become the axes of future synclinals, because "the heaviest portion would sink into the lighter colloid mass" underneath, protruding it laterally beneath the lighter portions where, by its lighter density, it tends to accumulate." He adds: "The resulting movements would be determined, first, by the amount of difference in the densities of the upper and lower masses, and, second, by inequalities in the thickness of the strata: the forces now become adequate to the building of mountains and the plication of strata, and their modes of operation agree with the classes of facts already set forth as the concomitants of those features."

The views are next applied to a system of plications. "It has been indicated that plications occur where strata have rapidly accumulated in great volume and in elongated narrow belts; that the axes of plications are parallel to the axes of maximum deposit; and that the movements immediately followed the deposition"—the case of the Appalachians being an example in which the accumulations averaged 40,000 feet. He observes: "Wherever the load of sediments becomes heaviest, there they sink deepest, protruding the colloid magma beneath them to the adjoining areas, which are less heavily weighted, forming at once both synclinals and anticlinals. If the difference in the densities of the upper and lower portions be small, the latter being a little less or but slightly plastic, the disturbance would not be great [and the undulations made would be low]; if this difference and the plasticity be considerable, the disturbance becomes not only greater, but assumes new phases [as in the Juras and Appalachians]; and finally when the two conditions become extreme, the phenomena become eruptive." The movements are hence according to hydrostatic law. He says further: "In mountain-making the disturbing agents have been extreme. All typical mountains consist of granitoid cores protruded through strata and towering above them"—as in the Sierra Nevada. "The thickness of the

Appalachians is from five to eight miles; the thickness of the Miocene strata of the Coast Range in California, according to Messrs. Brewer and King, is nearly five miles [5000 feet?]; and both systems bear every indication of being shallow-water deposits —in brief, coast and off-shore deposits. No geologist doubts that these strata subsided as they grew in thickness. But if they subsided they displaced the matter beneath them; and what becomes of the displaced matter?" In the case of the Appalachians "it must have gone to the south-eastward—toward the land whence the sediments were derived"—"the direction toward which gravitation would inevitably propel it." "In the Coast Range, the Uintahs, Wahsatch and the Park Mountains of Colorado, strata miles in thickness have sunk, and right at the upturned edges come up the towering granitoid mountains." "On the one hand, matter has been displaced and gone somewhere [southeastward], on the other, displaced matter stands revealed in immediate contiguity." The Uintah range is a good example. "Disregarding the enormous Cretaceous deposits, the freshwater Tertiaries turned up on the flanks of these mountains are 10,000 feet thick. That these beds subsided by their gross weight as rapidly as they grew admits of no shadow of doubt." "What became of the matter displaced by the sinking strata, and whence came the displaced matter which slopes down to their upturned edges, and how can the conclusion be avoided that they are one and the same?" In other words the granitoid core was extruded as the sinking went forward, or during the later part of it.

For further details respecting the theory we refer to the original memoir.

With regard to this new theory, we might reasonably question the existence of the colloid magma—a condition fundamental to the theory—and his evidence that water penetrates to profound depths in the earth's crust sufficient to make hydrous rocks. We might ask for evidence that the rocks beneath the Cretaceous and Tertiary, and other underlying strata of the Uintahs, were in such a colloid state, and this so near the surface, that the "beds subsided by their gross weight as rapidly as they grew." We might query whether, if the subsiding of the beds were causing at the same time a protruding, the seas would have been in a condition for living species or quiet deposition, and whether therefore the protrusion, if a fact, must not have been a final result after the deposition and the attendant subsiding had ended. We might query whether the granitoid core of some of the mountains referred to has been proved to be of the age the theory assumes. We might query also whether in the case of the Appalachians, the material of which the rocks were made came from land once existing to the southeastward; whether the various anticlinals and synclinals in different overlapping series, taking only the larger ones, could have corresponded severally to movements in a colloid mass below, to a sinking by weight where the material was thickest above, and so making the synclinals; whether in the case of the Appalachians,

the width of the synclinal formed as the Paleozoic deposits were in progress was not approximately as great as the width of the area of thickening depositions, and whether the anticlinal, made by the displaced plastic material beneath being pushed to the southeastward, was not at least as broad as the synclinal, so that one anticlinal and one parallel synclinal may have occupied together three hundred miles or more in breadth.

Captain Dutton observes that "plications occur where strata have rapidly accumulated in great volume," etc. This idea of *rapid* accumulation and brief work in mountain-making has occasioned, as shown in this and some other parts of his memoir, some misapprehension of the effects that would come from lateral pressure. The accumulation of material for the Appalachians, occupied the whole of Paleozoic time; and probably there is no geologist who believes that the length of that era was less than ten millions of years, and few that it was less than fifty millions. Even if it took one million, the accumulation was not rapid; and certainly not if it took fifty millions. Again, he says that the movements of mountain-making "immediately followed the deposition." "Immediately" sounds quick to one who appreciates the slowness of geological changes. The Carboniferous age was very long; and some where in that part of geological time, either before the age had fully ended, or some time after its close, the epoch of catastrophe began. But this catastrophe, according to the apprehension of geologists who best appreciate the rate of the earth's progress, may have taken one or more hundreds of thousands of years to have accomplished its results—time enough to have produced plications without chaotic effects.

2. *A Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country;* by F. B. MEEK. 609 pp. quarto, with an Introduction of lxiv pages, and 45 quarto lithographic plates, of about 1000 figures, constituting volume ix of the Report of the U. S. Geological Survey of the Territories, F. V. HAYDEN, U. S. Geologist in charge.—Mr. Meek's labors in connection with the Cretaceous and Tertiary fossils of the Rocky Mountain region began more than thirty years since, and, with some interruptions by work on the paleontology of other parts of the country, they have been continued ever since. He was engaged in the descriptions of the earliest invertebrate fossils collected in Nebraska by Dr. Hayden, and has always been referred to for descriptions of the species of the expeditions under Dr. Hayden's charge, and not of these alone. For the preparation of this new and great work he has therefore had the benefit of his previous long and labored study of the subject, and the command of all the species the Rocky Mountain expeditions have afforded. Mr. Meek works with extreme care and fidelity, and hence his results rank with the best.

The country in which the fossils described in his work were discovered lies mainly between the British possessions on the north, the Platte on the south, the Missouri River on the east and the Rocky Mountains on the west.

The Introduction to the volume, after presenting sketches of the earlier explorations in the Upper Missouri region, describes the formations from which the fossils were collected, giving sections showing the thickness and order of superposition of the various subdivisions. The geographical extension of the same west of the Mississippi is also shown; and their relation to the subdivisions of the Cretaceous in Mississippi, Alabama, New Jersey, and in the Old World are fully discussed. The author also makes some remarks on the mooted question in regard to the relation of the Lignites of the far-west to the Cretaceous and Tertiary systems, maintaining, as he had previously done, that these deposits belong in part to the Cretaceous and in part to the Tertiary: that is, that the beds at Coalville, Utah, and Bear River, Wyoming, are clearly Cretaceous, like those of Western Colorado; that those of Bitter Creek, Wyoming, especially those below the horizon of the Hallville coal, are almost certainly Cretaceous; that those above, to the horizon of the Saurian bed at Black Butte Station inclusive, probably belong also to the Cretaceous, but may be Eocene; and that the Evanston and Carbon Station coal-bearing strata of Wyoming are Tertiary.

The Judith river fresh- and brackish-water beds of Montana, and of British America, in which Cretaceous types of Saurians have been found, along with some Eocene types of vertebrates, and new species of shells that would be called Tertiary forms by almost any paleontologist (judging from their affinities), he thinks, *may* be Cretaceous, but he does not regard this conclusion as yet clearly established. The Fort Union fresh- and brackish-water Lignite group, of the Upper Missouri he regards as Tertiary.

In the body of the work, all of the known Upper Missouri invertebrate genera, subgenera, species and varieties, whether new to science or not, are fully described; and are also illustrated on the accompanying plates. The genera thus described number about 120, the subgenera, including the type sections, 170, and the species and varieties about 308. Full synonymy and references of all of the species and genera are given, and the type of each genus and subgenus, where known, is mentioned; and, where there is doubt as to the exact type-species, a typical example is cited. After the description of each genus a separate brief diagnosis of its subgeneric sections (if so divisible) is given, and an example cited.

The affinities and geological range, so far as known, of each genus, are also fully discussed; and when represented by existing species, its habits and geographical distribution are generally stated. Most of the species, and some of the genera in the work, are here for the first time illustrated.

Only a few of the species are known to occur in the old world, and at localities in this country east of the Mississippi; and these are all from the Cretaceous, and show that the Niobrara and Fort Benton Groups, as well as perhaps the Dakota Group, represent the Lower or Gray Chalk, with possibly also the Upper Green Sand;

and the Fort Pierre and Fox Hills Groups the Upper White Chalk, and, possibly, also the Maestricht beds of Europe.

3. *Shower of Volcanic dust over Scandinavia.*—In March of 1875, according to A. E. Nordenskiöld, a shower of volcanic dust fell widely over Sweden and still more abundantly over Norway, making a layer over some places a quarter of an inch thick. The dust was pumice-like in constitution. It is traced to Iceland. On the 30th of March the winds were northwest and west. An eruption began in Iceland in the preceding December, from numerous craters in the interior, and the most abundant ash-shower occurred over the island on the 29th of March, covering some pastures six inches deep; and if the ashes of the same shower reached Scandinavia, as is probable, the journey of 2000 kilometers was performed in less than twenty-four hours.— *G. Mag. for July.*

4. *Carrara Marbles.*--Prof. G. A. Lebour, in the Geological Magazine for July, mentions the discovery of Sub-carboniferous fossils in connection with Carrara statuary marbles; among them *Spirifer glaber*, *Leptæna arachnoidea* d'Orb., *Cardiomorpha pristina* de Kon., *Cardinia tellinaria* de Kon., *Pholadomya regularis* d'Orb., *Cyathocrinus quadrangularis* Miller, etc. The superior Coal-measure shales, at Monte Jano, contain *Neuropteris rotundifolia* Brngt., *Odontopteris Schlotheimii*, *Pecopteris arborescens*, *P. cyathea*, *Cyclopteris orbicularis*, *Annularia longifolia*, etc.

The St. Béat marbles, in the Pyrenees, are of the same Carboniferous limestone age.

5. *Markings supposed to have been made by man with stone implements on bones of a Balænotus of the Lower Pliocene of the valley of Fine, Italy.*—Capellini who described these markings to the R. Accademia dei Lincei, at the meeting of May 7th, states that the Balænotus was the same species described by Van Beneden from the Tertiary of Belgium. The marl-bed, containing the bones, he identifies with the Superior marl of the Vatican, belonging to the Lower Pliocene. His memoir will soon be published, with a plate.

6. *Serpentine and Eozoon.*—Dr. Dawson has a reply to the criticisms of Mr. Hahn, in the number of the Annals and Magazine of Natural History for July, and Dr. William Carpenter in the number for June. Dr. Carpenter mentions the discovery, by Prof. Möbius, of Kiel, in 1874, on a coral reef off Mauritius, of an incrusting foraminifer, which, in mode of growth and peculiarities of structure, approaches rather closely the Eozoon.

Dr. Dawson states that Mr. Richardson has found at Chibogomon, Canada, in a great bed of olive-green serpentine (a kind analyzed by Hunt) a specimen of tabulate coral, having many of its thin-walled hexagonal cells filled with serpentine, while others were filled with chlorite; and that a dark-green serpentine from Melbourne, Canada, envelopes fragments of shells, crinoids and corals, and also penetrates their pores and cavities.

Dr. Dawson has described (Quar. Jour. Geol. Soc., Feb., 1876) specimens of *Eozoon Canadense* from Côte St. Pierre, in the

Seigniory of Petite Nation, on the Ottawa, in a limestone of the Grenville band of Sir W. E. Logan, resting on bedded dioryte. Serpentine occurs in the limestone with the Eozoon, and also there is some dolomite, much of it without the Eozoon structure.

7. *Experiments on Schistosity in rocks, and on the deformations of fossils attending its production;* by M. DAUBRÉE (C. R., lxxxii, March 27 and April 10, 1876.)—The production of foliation in rocks is here discussed at length and illustrated by facts from experiments; and the results are made by Daubrée to include all examples of a schistose structure. His experiments were made by the hydraulic press used by M. Tresca in similar researches, and under the advice of this physicist. Clay containing fine sand forced through a cylindrical aperture was rendered foliaceous concentric with its surface; and if mica were mixed with it, the foliaceous structure was very perfect, the mica scales having taken a position parallel to the surface. The same micaceous clay forced through a rectangular aperture became foliaceous parallel to the surfaces of the rectangular prism obtained, the most of the mica being parallel to the larger faces. The larger the scale of mica the more perfect the parallelism. These clays thus made foliaceous called to mind, strongly, M. Daubrée observes, the foliaceous character of mica schist and gneiss. By the same process, the compression of fossils was illustrated and also the occasional subdivision of one into a series of separated parts. A belemnite was too firm to answer for the experiment; but a piece of chalk cut into the form of a belemnite gave precisely the fracture and separation of parts so often seen.

Daubrée states that in the production of the foliated or schistose structure, there is a sliding of the parts unequally *in the direction of the pressure and movement;* and this is its origin. It is not necessary that the substance should consist of visible particles; for Tresca obtained the structure even with metallic lead. Moreover a very slight movement is sufficient to produce a distinct foliation; and a slow one conducts to the same result as a rapid.

From the experiments Daubrée draws the wide conclusion that the schistose structure in gneiss and mica schist, as well as that seen less perfectly in some granite, may have been produced *by pressure and movement;* and that in the region of Mont Blanc, for example, movement under pressure of the protogine material when pressed out in a plastic condition was the cause of all the schistosity the rock presents.

Where gneiss, mica schist, quartzyte, limestone occur in alternating beds, as is often observed, with the foliation parallel to the planes of junction, they must of course be regarded as successive strata, and as foliated parallel to the bedding in consequence of the original bedding. This is sometimes proved to be the case by the presence of more or less perfect fossils in the limestone. Hence, the question whether in any special case, the schistose structure of gneiss or mica schist was occasioned by pressure or not, is to be ascertained by a direct study of the rocks in place.

8. *The Geological and Natural History Survey of Minnesota;* 4th Annual Report, for 1875; by N. H. Winchell, State Geologist, assisted by M. W. Harrington. 162 pp. 8vo. St. Paul, Minn. 1876.—This report contains a Report on Fillmore County, by Prof. Winchell, and others, on Olmstead, Dodge and Steele Counties, by Mr. Harrington, together with a long table of railroad elevations, and a Report on the General Museum, by Prof. Winchell. Colored geological maps are given of each of the above named counties, and also good illustrations of some of the rock-scenery. One of the latter represents a bluff of the Jordan sandstone at Lanesboro, with a remarkable concretionary structure, the concretions of which vary from a few inches to nearly a foot in diameter. The St. Lawrence limestone, Jordan sandstone and Shakopee limestone underlie the St. Peters sandstone and correspond to the Lower Magnesian limestone.

9. *Révue de Géologie* of Messrs. Delesse and Lapparent. Vol. xii for 1873 and 1874. 224 pp. 8vo. 1876. (P. Savy, éditeur).—A very convenient volume for the geologist, posting up the new facts and discoveries in lithological, stratigraphical and dynamical geology. We cite from it the following observations:

M. Gérardin has shown that the waters of subterranean streams, feeding artesian wells, contain no oxygen, as Péligot had before shown to be true of the water of Grenelle.

According to M. Ed. Jannettaz, the conductibility for heat of slaty rocks is much the greatest in the direction of the slaty structure. Thus the ratio is in a talcose slate (a hydromica slate?) from the United States 2·007; in argillyte (phyllade) 1·988; mica schist from Aurillac (Cantal) 1·82; in a ferruginous talc slate (hydromica slate?) making part of the itacolumites of Guyanne, 1·87; an argillyte of Angers, 1·6.

M. Cossa has observed that gneiss, granite, trachyte, basalt are decomposed more rapidly by water holding gypsum in solution than by pure water. Sæmann and Guyerdet have found that dolomite is easily decomposed by the same solution aided by a current of carbonic acid.

10. McCoy, *Paleontology of Victoria:* Geol. Surv. of Victoria; Decade III. 40 pp. roy. 8vo. Melbourne. (London: Trübner & Co.).—This decade contains descriptions and figures of remains of *Thylacoleo carnifex*, of some trilobites (species of Phacops, Forbesia, Lichas, Homalonotus), and of various Mollusks.

11. *Report on a Survey of a line to connect the waters of the Neuse and Cape Fear River in North Carolina, and of a line to connect the waters of Norfolk Harbor in Virginia, with the waters of Cape Fear River at or near Wilmington in North Carolina;* by Mr. S. T. Abert, U. S. Engineer. Engineer Dept. Senate Ex. Doc., 44th Congress, No. 35.—This Report contains much valuable matter on the physical features of the coast region of North Carolina and Virginia, and of the changes which have been and are still going on there as to the limits and depths of the Sound, and the extent and outline of the sea-made lands, and on the origin of those changes.

12. *Mines and Mineral Statistics of New South Wales*, compiled by direction of the Hon. John Lucas, M.P., Minister for Mines. 252 pp. 8vo, with maps and sections. Sydney, 1875.—Besides mining statistics, this volume contains much of geological interest. It includes an essay on the sedimentary formations of the country, by Rev. W. B. Clarke, and notes on the Iron and Coal deposits of Wallerawand and on the diamond fields, by Prof. Liversidge.

13. *Recently formed crystallized minerals of the thermal spring at Bourbonne-les-Bains.*—Brief notices of Daubrée's examinations of the remarkable mineral transformations at Bourbonne-les-Bains have been given in volume x of this Journal, at pages 228 and 391. They were from abstracts of his communications to the Académie des Sciences in 1875, in the Comptes Rendus, lxxx, 461, 604 and lxxxi, 182, 834, 1008. The completed memoir has recently been published with some additions, and is issued as a pamphlet of 48 pages, by Dunod, Paris. It is a thorough discussion of the characters, conditions of occurrence, and modes of origin, of the several species, together with many valuable suggestions as to the bearing of the various facts on problems in geology. We cite the following points, not alluded to in the previous notices. The minerals derived from the action of the water on bronze objects (medals, etc.) include, besides those mentioned, also cuprite, chrysocolla, oxyd of tin and melaconite; and those from the action on lead tubes, cerussite (carbonate of lead). Daubrée remarks that while the copper had formed sulphids, the tin of the bronze had changed to the oxyd, which is its usual condition in metallic veins. Cuprite (oxyd of copper) was found in octahedral crystals in a tube of bronze, along with melaconite and chrysocolla. One of the specimens of phosgenite was associated with crystals of anglesite and had the cubic form of galenite. Oxyd of lead or litharge is still another of the lead products.

The iron found in the baths has in some places given rise to a hydrous silicate of iron, gelatinizing with acids, as had been observed by Daubrée also at Plombières. Vivianite is another of the iron minerals.

In addition to the zeolites, chabazite, and harmotome, there is one in regular hexagonal prisms which Daubrée refers with a query to the species *chalcomorphite.* Still other species are aragonite and calcite, and an earthy hydrous alumina silicate, related to halloysite or the material known as *Savon de Plombières.*

The whole number of crystallized species found to have been formed in the bottom of the old Roman well is at least twenty-four. Daubrée remarks that they may be looked upon as results of experiment although the experiments have been in progress through twenty times the duration of a human life. The water contains only neutral salts in solution, and has a temperature from 58° to 68° Centigrade. It has made different compounds according to the different materials that were bathed by it; and these are of so various kinds as to illustrate well the association of minerals in some metallic veins. The changes were produced at

Bourbonne, as they were also at Plombières, within eight meters of the surface, and at a temperature but little elevated; how great, then, asks Daubrée, must be the transformations we should witness if we could descend to the deeper parts of the conduits of thermal waters; and what the changes that must have gone on at all times through the waters penetrating the earth's deeper rocks and fissures.

14. *Further notes on inclusions in Gems*, by ISAAC LEA, LL.D. 11 pp. 8vo. Philadelphia, 1876.—Dr. Lea, in continuation of his former paper on this subject, describes cavities and minute crystals observed by him in tourmaline; of a cubic form and including a fluid, in an emerald; blue, and 4-sided, in iolite; tubular cavities, with a cubic crystal with fluid in one cavity, in blue corundum of North Carolina; minute acicular crystals in corundum of Delaware Co., Pa., producing a bronze-like luster; and other results of his observations. The paper is accompanied by a lithographic plate.

15. *Geological Map of Europe.*—A small colored geological map of Europe showing the distribution of stratified rocks has been recently published in Petermann's Geographische Mittheilungen. It was prepared by Habenicht, and is an excellent map for one of the size—12½ by 15½ inches.

16. *New Minerals: Ihleite, Friedelite.*—Prof. Schrauf has announced a new mineral under the name *Ihleite*. It occurs as a yellow efflorescence on the graphite of Mugrau, Bohemia. Its composition is expressed by the formula $Fe_2S_3O_{12}+12H_2O$. (Anzeiger, Ak. Wien, March, 1876.) *Friedelite* is a hydrated silicate of manganese described by M. Bertrand. Its characters are as follows: Rhombohedral. Cleavage eminent, normal to the vertical axis. Two varieties, one with saccharoidal structure, the mass made up of hexagonal lamellæ, with perfect cleavage, and the other very compact, with the cleavage scarcely visible. Double refraction energetic, axis negative. H.= 4·75, G.= 3·07. Color rose-red; streak pinkish-white. Transparent in thin fragments, in the mass translucent. Composition, the mean of several analyses: SiO_2 36·12, MnO 53·05 (FeO tr), MgO, CaO 2·96, H_2O 7·87=100. Both varieties mentioned give the same composition; in fact they pass into one another. M. Bertrand writes the formula 4MnO, $3SiO^2$, $2H^2O$ ($Mn_4Si_3O_{12}$+2aq), and remarks that it seems to be somewhat similar to hydrotephroite (Dana, Min. 1868, p. 260). B.B. fuses easily to a black glass; in the closed tube gives water. Dissolves in hydrochloric acid with the separation of gelatinous silica. With the fluxes reacts for manganese.

Found at the manganese mine of Adierville, valley of Louron (Hautes Pyrénées).—*C. R.*, May 15, 1876. E. S. D.

17. *Analcite not isometric.*—Prof. Schrauf, (l. c.) from an examination of analcite crystals from Friedeck, Bohemia, concludes that the species (like leucite) cannot be referred to the isometric system. The simplest crystals show evidence of repeated twinning, and the angle between the cubic planes is 89° 30′, implying the

existence of a dome as twinning plane, with an angle of 44° 45′, and giving the axial ratio 1 : 0·991. Irregularities in the optical properties of analcite were observed by Brewster. E. S. D.

18. *Angewandte Krystallographie (Ausbildung der Krystalle, Zwillingsbildung, Krystallotektonik) nebst einem Anhange über Zonenlehre*, von A. SADEBECK. 284 pp. 8vo, with 23 plates. Berlin. 1876.—The present volume forms properly the second part of the Elements of Crystallography (of G. Rose) published by Prof. Sadebeck in 1873. The object of the work is to describe crystals as they actually appear in nature, not the ideal forms which are of only theoretical existence. The special subjects considered are: 1. hemimorphism and pseudo-symmetry, the latter arising from the natural distortion of crystals in certain axial directions; 2. twins, including their explanation theoretically, and also an enumeration of all the methods or laws of twinning observed in the different systems; 3. the method of growth of crystals, showing how each individual is gradually built up of minute sub-individuals, and thus giving an explanation of many irregularities observed not only on the surfaces of the planes, but also in the interior of crystals. This last subject is one of great theoretical interest, and in the discussion of it the author has introduced much matter which is new obtained from his own extensive researches; it is elucidated by many excellent figures. The last chapter of the work discusses the subject of zones, considered particularly by means of the Quenstedt method of projection.

E. S. D.

19. *New Journal devoted to Mineralogy and Crystallography.*—Professor Groth, in a letter to the editors dated Strasbourg, May 28th, 1876, announces the commencement of a new Journal for special mineralogy. The plan of this Journal embraces the following subjects:—theoretical, physical and chemical crystallography; investigations in regard to artificial crystals; monographs of single minerals especially in relation to crystallography; memoirs on the chemical composition and artificial production of minerals, descriptions of their methods of occurrence, their determination under the microscope; in a word the Journal will cover the whole field of mineralogy, with the exclusion of geology. The leading mineralogists of Germany and Austria are all interested in the project, and it is desired that those of other countries should also lend their support so that the Journal may gradually assume an international character. In addition to the original papers it is proposed to include references to mineralogical work wherever published. There are to be from six to eight numbers during the year, appearing every six or eight weeks with the exclusion of the vacation months. The chief editorial duty will be performed by Prof. Groth, with the especial coöperation of Prof. G. vom Rath of Bonn, and Prof. Klein of Heidelberg. The publisher is Engelmann of Leipzig.

The plan deserves the hearty support of all interested in this department of science.

III. Botany and Zoology.

1. *The Oaks of the United States;* by Dr. George Engelmann. Reprinted from the Transactions of the Academy of Science, of St. Louis, Missouri, vol. iii, no. 3. 1876.—Only 20 pages; but they are wholly to the purpose, and contain the leading results of the long and close scrutiny which Dr. Engelmann has given to this vexed genus of trees. The paper begins with an account of the deceptive character of the common western oaks, as exemplified by the common scrub oak of the Rocky Mountains, basing his narrative upon his personal observations of its forms in the valley and on the bordering bluffs and precipices, where the Arkansas leaves the mountains at Cañon City, Colorado. Here, at different heights and exposures, he found *Quercus Gambelii* (*Q. stellata*, var. *Uthensis*, DeC.), *Q. Gunnisoni*, *Q. undulata*, described by Torrey long ago from this district, *Q. pungens* of Liebman, in part, *Q. oblongifolia*, *Q. grisea*, and *Q. Drummondii* of Liebman,—"in herbarium specimens all distinct enough, but, looking around us, the very abundance of material must shake our confidence in our discrimination [since] within the compass of a few hundred yards we find not only the forms above distinguished, but numbers of others, neither the one nor the other, but which are intermediate between them, and clearly unite them all as forms of one single, polymorphous species. If one oak behaves thus, why not others? Thrown upon a sea of doubt, what can guide us to a correct knowledge?"

Dr. Engelmann reviews the principal characters, one by one, to settle their relative value; and, in doing so, brings out the main general results of his protracted and patient investigations in this field. The trunk, as to size attained, while it gives character to eastern species (only the southern live oak occurring both as large tree and shrub, and equally fruitful in both forms), fails on the Pacific slope to be a specific distinction. "Examining the *bark*, we at once become aware of the fact that the popular distinction between 'white oaks' and 'black oaks' is based on correct observation. The paler, ashy-gray bark of the former, and the darker or often nearly black color of the latter, correspond with the essential characters, and mark the two principal groups of our American oaks. The bark of the white oaks is inclined to be scaly or flaky, that of the black oaks is usually rougher and deeply cracked or furrowed." "Moreover, the *wood* of the white oaks is tougher, heavier, and more compact; is the only oak wood fit to be used by the wheelwright or cooper, and is, for their purposes, unsurpassed. The wood of the black oaks is brittle and porous, makes poorer fire-wood, and in barrels holds only dry substances." Dr. Engelmann states that, "instead of making narrower and narrower rings as they grow older, the oaks either hold their own, the annual rings being as wide in age as in youth, or they grow more rapidly after the first 50, 100, or even 150 years of their existence."

The winter buds give characters in some species. As to the shape of the leaves, so extremely variable, it is remarked, "that those oaks, which in the perfect state have deeply lobed or pinnatifid leaves, show in young shoots and on adventitious branchlets less divided or even entire leaves; while, singularly enough, the oaks whose leaves in the adult tree are entire, or nearly so, often have on the young shoots dentate or lobed leaves."

The vernation of the leaves, although more commonly conduplicate, both in white and black oaks, furnishes other types, which Dr. Engelmann has first brought into prominent view, and finds of great account in distinguishing allied species and doubtful varieties, and in unravelling intricate questions of hybridity or affinity. The nature of the down on young leaves may also be turned to use. The venation occasionally enables easily confounded species, such as *Q. agrifolia* and *Q. Wislizeni*, to be distinguished even in sterile branchlets.

The persistence of the leaves is a good character in some species, while in others it is of no account. The leaves of some oaks persist even to the third year. "Only such oaks ought to be called evergreen which retain the greater part of their old leaves, at least until the new ones are fully grown."

In the male flowers the size and number of the anthers furnish good distinctions, being small and mostly 5 to 10 in the white oaks, four or sometimes 5 to 6 and larger in the black oaks; the pubescence of the anthers distinguishes a few species, while their cusp is variable in several. The female flowers distinguish the principal groups, especially the styles, which in the white oaks are sessile or nearly so; in the black oaks always on longer and spreading or recurved styles. The annual or biennial maturation of the acorn, first indicated by Michaux, and the persistence and position of the abortive ovules, indicated by Alph. DeCandolle (in white oaks at the base, in black oaks near the tip of the perfect seed), and the scales of the acorn cup (thick and knobby in white, thin and membranaceous in the black oaks), are likewise noted. The comparatively thin shell of the acorn in white oaks is dark and smooth within, or rarely pubescent; in the black oaks the shell is thicker and lined with a silky down.

All these matters relate to the true oaks (section *Lepidobalanus*), with scaly acorn-cups, pendulous male catkins wholly apart from the solitary or distant female flowers. But in California we have, in *Q. densiflora* a representative of the otherwise Asiatic subgenus, *Androgyne*, "in many respects more a chestnut than an oak; for it has, just like the chestnuts, dense-flowered and erect male spikes, 10 stamens to each flower, very small anthers on long filiform filaments," female flowers crowded at the base of the male catkins, linear pointed stigmas, and a spinose cup, which, however, is that of an oak rather than like the prickly involucre of the chestnut.

The paper continues with a systematic enumeration of the 38 recognized species, and notes are appended to about half of them.

Finally, hybrid oaks are discussed; and six well determined ones are enumerated as known to the writer, three of which have been described as species, namely: *Q. Leana*, *Q. tridentata*, and *Q. sinuata*. One parent of four of these hybrids is *Q. imbricaria*; of the other two, *Q. cinerea*. The fact that some species of a genus are more prone to hybridize than others—which is also true of *Verbena*—is curious. Most botanists will learn with some surprise that *Q. heterophylla* of Michaux is received, not as a hybrid, but as a well-marked species, of the *Phellos*, *laurifolia*, and *aquatica* group. Dr. Engelmann's six real hybrids are all of the Black oak group: this group never crosses with White oaks; and no hybrid of the latter group is known to our author. The black oaks are now unknown in Europe; but we learn that they existed there, along with white oaks, in the tertiary period.

It must be difficult to discriminate between hybrids and intermediate forms of variation where the usual character, the sterility of the hybrid, is wanting, "and where we have nothing to rely on but the rarity and individuality of a form that seems to stand intermediate between two well established species which occur in its neighborhood, and which could be considered its parents. This is just the case in Oaks. All the supposed hybrids are abundantly fertile, and those of their acorns that have been tested have well germinated; in fact, as far as I know, no difference in fertility or germinating power between them and the acknowledged species has been discovered. The seedlings of such questionable individuals do not seem to revert to a supposed parent, a sport of which they might claim to be, but they propagate the individual peculiarities of the parent—'come true,' as the nurserymen express it. At the same time it is a remarkable fact, that, notwithstanding their fertility, they do not seem to propagate in their native woods. We may properly ascribe this to a lesser degree of vitality in the hybrid progeny, which causes them to be crowded out in the struggle for existence." There is another reason, to us a more probable one. The hybrid tree, when isolated in cultivation, is likely to self-fertilize and so be continued in its progeny; but in its native forest, surrounded and dominated by its two parents, its female flowers will almost inevitably be fertilized by the pollen of one or the other of them and so brought back in the progeny to that species. Indeed a single tree, so situated, practically has almost no chance at all of perpetuating its kind. A. G.

2. *M. Gustave-Adolphe Thuret; Equisse Biographique;* par M. Ed. Bornet.—This is the title of an article in the latest number of the *Annales des Sciences Naturelles*, an interesting and worthy tribute by Dr. Bornet to the director and companion of his studies and researches, to whom is left the sacred duty of completing them, so far as possible. To the full biography is appended a catalogue of M. Thuret's scientific publications. The best and fullest notice of Thuret in the English language is one by Dr. Farlow, of Harvard University, contributed to Trimen's Journal of Botany at the beginning of the year. A. G.

3. *Fragmenta Phytographiæ Australiæ, contulit Liber Baro* FERDINANDUS DE MUELLER. Vol. IX. Melbourne, 1876.—This ninth volume bears testimony to the untiring industry, zeal, and ability with which Dr. Von Müller keeps up his investigations into the botany of the adopted country for which he has done so much in various ways; and his *Descriptive Notes on Papuan Plants*, and other publications upon the botany of the Pacific Islands, show how, from his vantage ground, he widens the already ample field, making the most of opportunity, ever active himself, and inciting and directing the activity and advantages of others. A. G.

4. *Flora Brasiliensis*, ed. AUG. GUIL. EICHLER.—The *Compositæ* of this great flora are undertaken by Mr. J. G. Baker of Kew, a new hand in this order, but capable of doing good work in this department, as well as among the Monocotyledons. Fascicle 62, issued in 1873, contained the *Vernoniaceæ*, with 50 plates. Fasc. 69, issued early in the present year, contains the *Eupatoriaceæ*, with 52 plates. The two fascicles compose vol. vi, part 2, with 398 pages of letterpress and 102 plates. The enlightened and active-minded emperor, Dom Pedro, may be well pleased at having such a flora of his empire, and at the prospect of its early completion. A. G.

5. *The Forest: Products of Michigan at the Centennial Exposition;* by Prof. J. W. BEAL, of the State Agricultural College.—A pamphlet of 16 pages, 8vo, giving an account, not only of the collection exhibited, but of the trees of the State, both the common and the rare species, their characteristics and their uses. There is a record of the larger trees of each species known in Michigan, which is now interesting and may hereafter become more so, if the individual trees are well identified. As to high trees: "At Clam Lake an old lumberman informed me that he could furnish spars of pine 175 feet long and not over two feet through at the butt. He had cut them 200 feet long." A. G.

6. *Contributions to the Flora of Iowa*, a catalogue of the Phænogamous plants; by G. C. ARTHUR. 1876.—A neat catalogue; with an appendix containing descriptions—generic and specific—of the species detected in Iowa which are not in Gray's Manual, twenty or so in number, and good notes upon some others. A. G.

7. *Locust invasion of* 1874.—Mr. G. M. Dawson has published a paper in the Canadian Naturalist on the Locust invasion of the country north of the United States. He remarks that they appeared in Manitoba in 1818, and from there have caused serious destruction in ten years, and been observed fifteen seasons. In 1874 none were hatched from the egg east of the 103d meridian, but in Dakota, some were hatched as far east as 99° W. The invasion in 1874 began late in June and continued during July, the direction of flight being between east and south. The most astonishing fact "is the fixed determination of the swarms to travel in a certain direction, and the wonderful instinct which leads them to a wind favoring their intention." One year they

reached the shores of the Lake of the Woods, long. 96° W. They do not eat sorghum or brown corn, and the *Leguminosæ* (pea and bean family) are decidedly disliked, while potatoes, tomatoes, and beets are usually exempt. Mr. Dawson asks whether this dislike for *Leguminosæ* may not account for the existence of a vast number of such plants on the western plains.

8. *United States Geological Survey of the Territories.* Volume X, *Monograph of the Geometrid Moths*, by A. S. PACKARD. Washington, 1876. 4to, with 13 Plates.—This is the first complete treatise on the North American species of the families of moths which Dr. Packard, following Guenée, calls *Phalænidæ*. The work is of extreme value in the present state of our knowledge of this group, for it presents us with a compilation of the literature, and from its original matter it must remain a standard of reference on the subject. Between three and four hundred species are described in the present work, while the author estimates the probable number of species occurring over our territory as "nearly a thousand." In the allied family of *Noctuidæ* we have catalogued nearly twelve hundred species, and estimate the number of species at over fifteen hundred. Dr. Packard's work is remarkable for the amount of labor expended on the generic and specific descriptions, which cannot be undervalued. The introductory chapters are of special interest, as also the concluding essay on geographical distribution. We miss an analytical table of the genera. In a work of this pretension it should not be wanting. The author finds occasion to prefer De la Guenée's work (Species Générales) to Lederer's on the moths. It is undoubted that Guenée's work on the *Phalænidæ* is superior to his work on the *Noctuidæ*. In the latter family we have found his genera largely inconsistent, and throughout important characters (e. g. the vestiture of the eyes, the armature of the tibiæ, etc.,) are totally neglected. We place his systematic work as undoubtedly lower than Lederer's, who stands at the head of all writers on the subject of genera in the two great families of the moths above mentioned. To Guenée we are disposed to give the greatest praise for his descriptions of species. Dr. Packard begins his work with the lower genera, ascending to the higher; so that the usual arrangement of the material is reversed. In the absence of a similar treatment of the other families of Lepidoptera, this change is a disadvantage to the student in arranging his collections.

In the synonymy Dr. Packard adopts the Hübnerian genera, from the Tentamen, as Mr. Scudder has done with regard to the Butterflies and we have done in the *Noctuidæ* (List of the N. Am. *Noctuidæ*, 1874). No other course is open to the systematist. Dr. Packard is fortunate in having so large material as to be able to unite several species hitherto regarded as distinct (e. g. the species of *Drepanodes* and *Ellopia*); with regard to the species of *Ellopia* Dr. Packard says: "If I had had Mr. Grote's types alone of male *E. bibularia* and female *pellucidaria*, I should have regarded them as distinct." Perhaps in uniting *Endropia amœnaria* and *E. arefactaria* Dr. Packard may prove less fortunate. In the generic names adopted we find a few which will not stand. *Eu-*

gonia is preoccupied in the Butterflies. *Eutrapela* must be used for *Kentaria* and *Alciphearia*; *Chœrodes* for the genus called *Eutrapela* by Dr. Packard. The plates are worthy of great praise, and will bear the most critical inspection. The numerous general figures were drawn on stone by Trouvelot. Dr. Hayden is to be heartily congratulated on the publication of this volume, which reflects much credit upon his judgment and the scientific standing of the Geological Survey, and Dr. Packard deserves the gratitude of entomologists for his treatment of the subject. A. R. G.

9. *Tabulate Corals.*—Dr. G. Lindström, in a paper a translation of which is given in the Ann. Mag. Nat. Hist. for July, discusses with judgment the relations of the tabulated corals. He refers the *Millepora* to the Hydroids (adopting Agassiz's conclusion); *Favosites* to the Poritinæ (following Verrill) with *Rœmena*, *Striatopora* Hall, etc.; *Heliolites*, *Halysites*, *Lyellia* E. & H., *Plasmopora* (with *Propora*) E. & H., *Calapœcia* Billings, *Thecostegites* E. & H., to the Heliolitidæ; *Heliopora* and *Polytremacis* to the Alcyonaria; *Chœtetes*, *Monticulipora*, *Dania*, *Stellipora*, *Alveolites* in part, *Fistulipora* in part, to the Bryozoa: *Pocillopora* (following Verrill) to the Oculinidæ, with, probably *Seriatopora*; *Columnaria*, to the Cyathopyllidæ; *Fletcheria* and *Michelinia* to the Cystiphyllidæ; *Syringopora*, to the vicinity of Lithostrotion and Diphyphyllum.

10. *Rafinesque's Ichthyologia Ohiensis.*—Dr. D. S. Jordan has a paper giving the equivalents in modern nomenclature, so far as were ascertainable, of the species of fishes named by Rafinesque, in the Bulletin No. 3 of vol. iii of the Buffalo Society of Natural Sciences. The same number contains also a check-list of the fishes of the freshwaters of N. America by Dr. Jordan and H. E. Copeland, and a synonymic list of the Butterflies of N. America, north of Mexico, by S. H. Scudder.

11. *Synopsis of American Wasps;* by Henri de Saussure of Geneva, Switzerland. *Solitary Wasps.* Smithsonian Miscellaneous Collections, No. 254. 386 pp. 8vo, with 4 plates. Washington, December. 1875.

12. T. Lyman, *on Ophiuridæ and Astrophytidæ* collected by the Hassler Expedition and Dr. Wm. Stimpson. Illustrated Catalogue of the Mus. Comp. Zool. at Harvard College. No. VIII. 34 pp. 4to, with five excellent plates.

13. *Bulletin of the U. S. National Museum, published under the direction of the Smithsonian Institution*, No. 4. Birds of Southwestern Mexico, collected by F. E. Sumichrast, prepared by G. N. Lawrence. 56 pp. 8vo.—No. 5. Catalogue of the Fishes of the Bermudas, by G. Brown Goode. 82 pp. 8vo. Washington, 1876.

Catalogue of the Stalk- and Sessile-Eyed Crustacea of New Zealand, by Edward J. Miers, F.L S., Assist. Zool. Dept. Brit. Mus., Colonial Museum and Geological Survey Department, James Hector, M.D., Director. 136 pp. 8vo, with 3 plates. London, 1876.

Catalogue of the Birds of Kansas, by F. H. Snow. 3d ed. 14 pp. 8vo. Nov., 1875.

List of Skeletons and Crania in the Section of Comparative Anatomy of the U. S. Army Medical Museum.

IV. Miscellaneous Scientific Intelligence.

1. *On Oceanic Circulation;* by Wm. B. Carpenter.—The very decided expression of opinion on the part of Professor Wyville Thomson, to which currency is given in the *Athenæum*, against the doctrine of "a general vertical circulation of the water of the ocean, depending on differences of specific gravity," is far from being decisive of the question; and might, perhaps, have been advantageously withheld, until my friend should have learned, on his return home, what progress has been made towards its solution by physical inquiry, during his three and a half years' absence.

If he had been present at the Bristol meeting of the British Association, he would have learned, from Mr. Froude's experimental confirmation of the "wave-line theory" of our greatest mathematical physicists, that *friction of water upon water* is so small an obstacle to its movement, that it may be practically disregarded; so that very small disturbances of the static equilibrium of ocean water—whether produced by diversities of temperature, or by alterations of its salinity—*must* give rise to a movement tending to its restoration, without the necessity of any appreciable "gradient." And he might have further received from Mr. Froude (as I had the advantage of doing) the confirmatory evidence on this point furnished by his extended observations on harbors, lochs, and fiords; to the effect that wherever the specific gravity of the surface-water of any such inlet of the sea is reduced by a river efflux, an under-current of sea-water is forced inwards by the excess of pressure outside. At the same meeting, my friend would have heard Sir William Thomson, commenting upon Mr. Croll's asserted disproof of the "gravitation theory," give the full weight of his great authority to the doctrine (originally propounded by Lenz in 1845) of a vertical oceanic circulation sustained by opposition of temperature; Sir William emphatically declaring it to be a matter "not of opinion, but of irrefragable demonstration."

If, again, Prof. Wyville Thomson had enjoyed the advantage of meeting the distinguished foreign physicists, Prof. Möhn, of Christiania, and Prof. Buys Ballot, of Utrecht, who recently came over to attend the Meteorological Congress in London, he would have found them entirely satisfied of the truth of the gravitation doctrine; and would have received from the former the following remarkable exemplification of it:—

Outside the coast of Norway, there is a deep channel, along which a flow of glacial water can be traced southward as far as the Cattegat. This flow cannot possibly be accounted for by any "excess of evaporation over precipitation;" for it proceeds towards an area that receives a large river efflux from the Christiania fiord, as well as the efflux of weakly-saline water from the Baltic. And it is unhesitatingly attributed by Prof. Möhn to the relative excess of downward pressure over the northern end of the trough, constantly maintained by the reduction of downward pressure over its southern extremity, which results from the admixture of fresh water.

Until, therefore, Prof. Wyville Thomson shall have been able to disprove these results of combined theoretical and practical research, by showing that differences of specific gravity, produced by differences either of temperature or of salinity, will *not* produce movements in oceanic water tending to the restoration of its disturbed equilibrium, I venture to affirm that his *dictum* will not find acceptance with the physicists who have most carefully studied the question. His present doctrine, that the underflow of polar water is an indraught due to "the excess of evaporation over precipitation," is as much opposed to physical theory as his former doctrine that the indraught is due to the sweeping away of equatorial water by the trade winds, which was unhesitatingly pronounced untenable by the distinguished physicists who discussed it at the last Edinburgh meeting of the British Association. For they were unanimous in affirming that a removal of surface-water from any area will be replaced by a surface inflow (where this is unrestricted), rather than by an indraught from beneath. And it seems to me no less in contradiction to the facts of the case. For the Challenger observations have afforded the fullest confirmation of the two fundamental positions of Lenz's doctrine:—(1) The near approach of polar water to the surface under the equator; and (2) The marked inferiority in the salinity of equatorial surface-water as compared with that of the tropics. The first of these facts shows that the updraught of polar water is nowhere so strong as it is under the equator; the second proves that, in some way or other, the loss by evaporation in the equatorial area is more than replaced, so that it can occasion no such updraught.

These two facts were considered, by one of the ablest physicists of his time, as capable of no other explanation than that afforded by the doctrine of a vertical oceanic circulation, of which the *primum mobile* is the excess in the specific gravity of polar water, causing its continual descent and a complemental ascent in the equatorial zone.

I am far from affirming that "excess of evaporation over precipitation" has no influence in producing movements of ocean water; on the contrary, I have shown that it is the *vera causa*, not only of the surface in-current, but of the outward under-current, of the Gilbraltar Strait. And it is, doubtless, one of the agencies at work, whenever it operates strongly over a localized area.

The problem of Oceanic Circulation, in fact, is rendered one of great complexity by the number of such agencies, and the great variety in the local conditions under which they respectively operate. And since, in the discussion of the vast body of valuable observations collected by the Challenger, it will be of the first importance that the principles on which that discussion is to be based should be settled by the highest authorities in physical science, I trust that at the ensuing meeting of the British Association at Glasgow, an opportunity may be provided for a full and free debate, in which Prof. Wyville Thomson, Mr. Croll, and I, may set forth our respective views in friendly antagonism, and

may submit them to the judgment of the distinguished physicists who will doubtless be there assembled.

To such a judgment I pledge myself implicitly to bow; no one being better aware than myself of the disadvantage under which I labor in possessing no more than an elementary knowledge of physical doctrine.—*Athenæum*, May 13.

2. *Reclamation.—Letter to the Editors, from Mr. George Davidson, U. S. Coast Survey*, dated San Francisco, March 7, 1876.—In the March number of your Journal (No. 63, vol. xi,) Article xxix, by Professor Lovering, the statement is made that "the late Professor Winlock [in February and March, 1869] sent electrical signals from Cambridge to San Francisco, and thence by other lines to Canada, and back again to Cambridge, over a loop of wire measuring 7200 miles."

Professor Winlock and I were always in full accord in this and other matters, and I am sure he never made the above claim. On the contrary, he gave me full credit for the inception of the experiments, and the successful determination of the wave time over a loop of wire of 7200 miles with the batteries and repeaters in line. The experiment was a necessary consequence of the telegraphic longitude operations of the United States Coast Survey between Cambridge and San Francisco.

Moreover, the experiment was not made at Cambridge; it was made by me in the Coast Survey Observatory at San Francisco, and the loop was made by Professor Winlock at Cambridge. The signals were transmitted from my clock to Cambridge, and to other stations and back; and as Cambridge did not have the necessary instrument for such a record, Professor Winlock devised a means of sending and receiving clock signals over a single wire; unfortunately the cable across the Golden Gate broke after passing the first series, and no more were undertaken.

The whole work is fully detailed in the records of the Coast Survey, and, by permission of the Superintendent, the results and *modus operandi* were verbally communicated by me to the California Academy of Sciences.

If, however, the details of my work and of Professor Winlock's device are of any interest to experimentalists, I can readily supply them from the original memoranda.

3. *Men of Science, from abroad, at the U. S. International Exhibition.*—No occasion has before drawn together so many distinguished men of science from abroad, in various departments, as the Centennial Exhibition at Philadelphia. Without attempting to enumerate all whose names might properly be mentioned in this relation, we recall, from Great Britain, Sir WILLIAM THOMSON, the well-known physicist who is President of the Judges on the XXVth Group—Instruments of Precision and Research; Sir JOHN HAWKSHAW, the eminent engineer who was last year President of the British Association; Sir CHARLES REED, President of the XXVIIIth Group of Judges—for Education and Science; Capt. DOUGLAS GALTON, President of the Judges under the XVIIIth Group—Railway Plans, etc.; Mr. ISAAC LOWTHIAN BELL, the

most eminent iron metallurgist in Great Britain, and author of the well-known treatise on the 'Chemistry of the Blast Furnace,' President of the Judges of Group I—Minerals, Mining, Metallurgy, etc.; Dr. WILLIAM ODLING, Waynflete Professor of Chemistry in the University of Oxford, Secretary of the board of Judges on Group III—Chemistry and Pharmacy, etc.; from Sweden, Prof. ADOLF E. NORDENSKIÖLD, Prof. C. A. ANGSTRÖM, Polytechnic Institute, Prof. O. M. TORELL, Chief of the Geological Survey of Sweden, and RICHARD ÅKERMAN, of the Royal Swedish School of Mines, all from Stockholm, under whose immediate superintendence the excellent geological, mineralogical, and metallurgical display of Sweden, at the Exposition, has been made; from Russia, Major General AXEL GADOLINE, an eminent Russian engineer, and Prof. L. NICHOLSKY, Mining Engineer and adjunct Professor at the Mining School of St. Petersburg, who is in charge of a systematic collection of Russian minerals—the only systematic mineral collection in the Exposition; from Germany, Dr. WEDDING, Royal Prussian Counsellor of Mines, Dr. RUDOLPH VON WAGNER, the well-known Editor of Wagner's Jahresbericht, and Dr. G. SEELHORST, of Nuremberg; from France, Mr. L. SIMONIN, J. F. KUHLMAN (fils), M. E. LEVASSEUR, and M. EMILE GUIMET, of Lyons; from Italy, Prof. EMANUEL PATERNO, of Palermo; from Mexico, MARIANO BARCENA, the mineralogist.

The Emperor of Brazil, without claiming the position of a man of science, manifests the most intelligent and cultivated understanding of all that is most worthy of notice in scientific methods, his enquiries extending to everything which should interest the Head of a great Continental Empire.

Prof. Nordenskiöld on July 1st, left on his return, to join a new expedition of discovery to the seas of Northern Siberia.

4. *Connection of the Caspian and Black Seas.*—It is reported that the connection of the Caspian and Black Seas by a canal, and a raising thereby of the surface of the Caspian—now below sea-level—is under consideration. The length of the proposed canal would be 240 kilometers, and the width to the eastward about 170 yards, and to the westward about 110 yards. A second project, complementary to this, is the junction of the Don and Volga, and the turning thus into the Caspian of the larger part, if not the whole of the former river. The project has been proposed to the Russian Government by an American company.—*L'Institut*, 28 *Juin.*

5. *Geographical Survey of the State of New York.*—The board appointed by the act of the last Legislature to make a trigonometrical survey of the State, have adopted resolutions to the effect that an officer shall be appointed, with the title of Director, whose duty it shall be to prepare and submit to the consideration of the Commission plans for conducting the survey, with estimates thereof, and under the direction of this board to organize, superintend, and manage the work required for carrying out such of these plans as shall be approved; that the Director shall nominate suitable assistants for the required duties of the survey, and that none shall be appointed unless nominated by him; that the Di-

rector and all other officers shall hold office during the pleasure of the board; that the salary of the Director shall be $4,000 per annum, including expenses. Under the first resolution the board proceeded to choose a Director, and Prof. James T. Gardner, at present Secretary of the American Geographical Society, was elected.—*N. Y. Times*, July 13.

6. *Appalachia*, June, 1876, vol. I, No. 1, 62 pp. 8vo. Boston: A. Williams & Co. Published for the Appalachian Mountain Club.—The Appalachian Mountain Club was organized in 1876 "for the advancement of the interests of those who visit the Mountains of New England and adjacent regions, whether for the purpose of scientific research or summer recreation." The Club proposes to carry on a systematic exploration of the regions referred to, both topographical, geological, and artistic. The President is Prof. E. C. Pickering, Vice President S. H. Scudder, and Secretary J. B. Henck, Jr., of the Technological Institute, Boston. The papers contained in this first number of the publications of the Club, are a Report on the Nomenclature of the White Mountains; an abstract of a paper on the "Atlantic System of Mountains," by C. H. Hitchcock; a day on Tripyramid, by C. E. Fay; on two new forms of Mountain Barometer, by S. W. Holman; a new map of the White Mountains (with a Map) by Mr. J. B. Henck, Jr.; on the East Branch of the Pemigewasset, by W. Upham; together with reports of the Councillors for the spring of 1876, containing suggestions of work proposed for the summer.

7. *American Association for the Advancement of Science.*—The 25th meeting will commence at Buffalo, N. Y., August 23. Members on arrival will find the Permanent Secretary at the Tifft House. By means of certificates, obtainable of the Permanent Secretary, at Salem, Mass., tickets at reduced prices may be had on the following railroads: Erie, Grand Trunk, Canada Southern, Great Western, Pennsylvania, Lake Shore and Michigan Southern, Cleveland, Columbus, Cincinnati and Indianapolis, New Orleans, St. Louis and Chicago.

8. *Elements of Physical Geography*, for the use of Schools, Academies and Colleges; by Edwin J. Houston, A.M., Prof. Phys. Geog., and Nat. Phil., Central High School, Philadelphia. 158 pp. sm. 4to, with many illustrations. Philadelphia, 1876. (Eldredge & Brother.)—An excellent text book well adapted for school instruction. The numerous illustrations are beautiful and include several colored maps.

9. *Proceedings of the Poughkeepsie Society of Natural Science*, vol. i. 42 pp. 4to.—This first number is occupied with an article giving the views of Mr. Charles B. Warring, in an article entitled "Studies upon the Inclination of the Earth's Axis."

10. *Transactions of the Kansas Academy of Science*, vol. iv. 62 pp. 8vo. Topeka, 1875.—This volume contains papers by Prof. W. K. Kedzie, on ozone in the Kansas atmosphere, and on the Nebraska hot bluff (hot through the oxydation of pyrite); G. E. Patrick, on the Kansas chalk, analysis of Kansas soils, and on Kansas salt; M. V. B. Knox, on Kansas Mammalia; G. F.

Gaumer, on the habits of some larves; W. Osburn, on the Cottonwood leaf-beetle; F. H. Snow, on the Rocky Mountain Locust, the larve and chrysalis of the Sage Sphinx, Catalogue of the Lepidoptera of E. Kansas (503 species), and Meteorological Summary for 1875. The meteorological summary states that the amount of rain (including snow) at Lawrence, Kansas (38° 58′ N., 95° 16′ W., at an elevation above the sea-level of 884 feet) was 28·87 inches, the same as for 1874, but 4·11 inches below the average rainfall of the last eight years.

11. *hkl.*—A new mineralogical society has been formed in England, styled the *hkl*, having Prof. Miller as its President.

Medical Statistics of the Provost Marshal General's Bureau. Compiled under the direction of the Secretary of War, by J. H. Baxter, A.M., M.D. Vols. I. and II. Thick 4to. 1875.

Principia or Basis of Social Science; by R. J. Wright. Second Edition. 542 pp. 8vo. Philadelphia, 1876. (J. B. Lippincott & Co.)

OBITUARY.

Porter Poinier, only son of Elisha B. and Frances A. Poinier, of Newark, died in New York city on Sunday afternoon, June 11th, aged 23 years. He had given himself to the study of Physics, and in the Polytechnic Institutes of Troy and Hoboken, he had thus early developed a very remarkable genius in the department of applied science. His studies had led him, with great success, into original investigations of heat as a force in nature, and his thorough and accurate and independent researches in this direction had attracted the favorable notice of the faculties under whom he studied. He attained to such important results as were found worthy of public notice, and he was engaged in the preparation and publication of an original work on the Dynamics of Heat, with the approval of his professors. His enthusiasm drank up his spirits, and utterly exhausted his physical force. Before he was aware, he was in the advanced stages of an incurable disease, and, while laboring to put his work through the press at Cambridge, he was pronounced beyond recovery. All his ardor in study was suddenly quenched by disease, and sadly he fell in the midst of his successes.

His very rare attainments and his extraordinary promise in the field of research had been brought to the notice of the Johns Hopkins University at Baltimore, and the day after his death, only too late for his noble ambition, came the certificate from the heads of the University, appointing him to a Fellowship in that institution. As a lecturer in the department of his special and successful study he had become familiar with the best French and German works in modern science, and his accuracy and perseverance and thirst for knowledge gave him promise of a very eminent future as a scientist. Such a young man, of unblemished morals, of pure and lofty aims, gifted with faculties of so high order, already attracting the attention of the learned, and laying down his life for truth as revealed in God's Book of Nature, trained, withal, to the highest of sciences in the written revelations, and searching for the truth of Christ, such a young man fills a large space and dies leaving a sad void. J.

THE

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[THIRD SERIES.]

ART. XXI.—*On the Gases contained in Meteorites.* Second paper; by ARTHUR W. WRIGHT, Yale College.

IN a previous article, published in this Journal, April, 1876, the writer gave the results of investigations upon the nature of the gases evolved from a number of meteorites of both the iron and the stony classes, when exposed to a more or less elevated temperature. The stony meteorites examined were all of the more common type, containing a considerable percentage of nickeliferous iron, without any appreciable quantity of uncombined carbon. As is well known, however, among these bodies of the stony kind, the meteorites of Alais, Kold Bokkeveld, Kaba, and Orgueil, form a distinct class, differing from the rest in several particulars, and especially in containing considerable proportions of amorphous carbon, and a bituminous substance consisting of carbon combined with oxygen and hydrogen in such a way as to simulate organic products. They are further distinguished by containing only very small quantities of metallic iron. As it seemed of interest to determine whether the conclusions arrived at in the investigations previously described were applicable to the bodies of this peculiar class also, the work was continued, with the results given below. Several other points of importance, referred to in the previous paper, were investigated, and are discussed in subsequent paragraphs.

The material used for the determinations was a fragment of an excellent specimen of the Kold Bokkeveld meteorite in the cabinet of Yale College. It contains an inconsiderable propor-

tion of metallic iron, though this is not entirely absent, for, on filing away the surface, very minute particles may occasionally be seen. The analysis made by Harris* gives for the carbon 1·67 per cent, and for bituminous matters 0·25 per cent. As has been shown by Professor J. L. Smith,† the mineral constituents are not greatly different from those of the ordinary stony meteorites. The method employed for the evolution and collection of the gases was essentially the same as that described in previous papers, and need not be given in detail here. It is sufficient to mention that, as the meteorite gives off a large amount of water on being heated, the tube containing the substance was connected with the pump by a recurved tube, the bend of which was placed in a freezing mixture during the evolution of the gas, in order to collect the water and prevent it from entering the pump. This tube was sealed with a gas flame at the close of the experiment and the water retained for examination. The temperatures employed for driving off the gaseous contents were nearly the same as those of the previous experiments, being however slightly lower, in order to avoid as far as possible complication of the results by the action of the heat upon the bituminous matter. The results were as follows:

Kold Bokkeveld.

	CO_2.	CO.	CH_4.	H.	N.	Volumes.
300°–350°	87·34	5·08	5·93	trace?	1·65	7·45
500°	95·53	1·32	2·14	0·54?	0·47	17·78
Total.	93·11	2·42	3·25	0·38?	0·84	25·23

The volume of the gases obtained is much greater in this than in the previous determinations; but it will be seen that in its composition the gaseous mixture is similar to that derived from the ordinary stony meteorites, with the exception of the hydrogen, of which, if any was present, the quantity was so small as to make its determination a matter of some uncertainty. The percentage of carbon di-oxide is somewhat larger at the higher temperature than in the other cases, but the real difference here is less than it appears, as the increase in the quantity of hydrogen evolved at the higher temperatures from the specimens which contained metallic iron, produced a corresponding diminution in the percentage of the carbon di-oxide; neglecting this, the proportions would show a much closer correspondence. It seemed probable that, at least at the higher temperature, an appreciable quantity of some hydrocarbon of the olefiant series, that is, with more carbon atoms than are contained in marsh-gas, might be found. But both the analyses, and special tests

* C. Rammelsberg, Die chemische Natur der Meteoriten. Abhandl. der Königl. Akad. zu Berlin, 1870.

† This Journal, III, xi, p. 391.

of the gas with fuming sulphuric acid, showed that the quantity of such substances possibly present was too small to carry it beyond the range of the ordinary errors of observation. The bituminous substance would thus appear to have been simply volatilized by the degree of heat employed, and condensed again in the cooling-tube without decomposition. No attempt was made to collect it separately.

The amount of water driven off by the heat and collected in the cooled tube was found to be about ten per cent of the weight of the substance employed, but the determination was not entirely satisfactory. Faraday found for the water 6·5 per cent. Wöhler states that the powder dried at 120° lost 10·5 per cent more by stronger heat. Rammelsberg found that the total loss at a strong heat was 15·24 per cent, but this of course includes, besides the water, the gases evolved and the volatile bituminous substance, as well as some sulphur, which was observed to be volatilized. The water, on the application of the ordinary tests, gave distinct evidence of the presence of chlorine, and less certainly of sulphurous oxide, resembling in these respects that derived from other meteorites. A small quantity of a light yellowish substance was deposited in the cold part of the tube, which appeared to be sulphur, but was not specially examined.

The differences in the gaseous products obtained from meteorites of the different classes may be made more apparent by bringing together the results of analyses hitherto made. The following table gives the total percentage of the gases yielded by the different specimens, the first seven being irons, the remainder belonging to the stony class. It represents the composition of the total amount of gas given off up to incipient or low red heat, except in the first two instances where the temperature employed was much higher.

Iron meteorites.	CO_2.	CO.	CH_4.	H.	N.	Vol.	Observers.
Lenarto,	4·46	0·00	...	85·68	9·86	2·85	Graham.
Augusta Co., Va.,	9·75	38·33	...	35·83	16·09	3·17	Mallet.
Tazewell Co., Tenn.,	14·40	41·23	...	42·66	1·71	3·17	W.
Shingle Spr., Cal.,	13·64	12·47	...	68·81	5·08	0·97	W.
Texas,	8·59	14·62	...	76·79	0·00 ?	1·29	W.
Dickson Co., Tenn.,	13·30	15·30	...	71·40	0·00 ?	2·20	W.
Arva,	12·56	67·71	...	18·19	1·54	47·13	W.
Stony meteorites.							
Iowa Co.,	49·51	2·64	0·0 ?	43·93	3·92	2·50	W.
Guernsey Co., Ohio,	59·88	4·40	2·05	31·89	1·78	2·99	W.
Pultusk,	60·29	4·35	3·61	29·50	2·25	1·75	W.
Parnallee,	81·02	1·74	2·08	13·59	1·57	2·63	W.
Weston,	80·78	2·20	1·63	13·06	2·33	3·49	W.
Kold Bokkeveld,	93·11	2·42	3·25	0·38 ?	0·84	25·23	W.

In the case of the last of these meteorites the number given in the table does not express the whole volume of gas contained in it, as the experiment was discontinued before it ceased to be given off. A special determination made with a separate portion gave a little more than thirty volumes. The Arva meteorite also is exceptional, both as regards the volume of gas yielded by it, and with respect to the large volume of the carbonic oxide obtained. We are reminded, by this fact, of the Ovifak iron, from which Wöhler obtained, by heating it to redness in an iron tube, more than 100 volumes of gas which was found to be carbonic oxide mingled with a little carbon di-oxide.* He attributes it, however, to the action of the carbon upon some oxygen compound, and the mass was found to contain a large quantity of magnetic oxide of iron. Doubtless the result was affected by the employment of the iron tube, which would rapidly reduce the carbon di-oxide at such a temperature. Berthelot, who examined another portion, at M. Daubreé's request, obtained by slow calcination in a tube of Bohemian glass a large volume of gas, the precise amount of which is not stated, consisting chiefly of the two oxides of carbon in nearly equal quantities.† The celestial origin of the Ovifak iron is very doubtful, however, and its composition is different from that of the Arva meteorite, in which no oxygen compounds were detected.

A few words need to be said with reference to the volumes quoted in the case of the Tennessee, Texas, and Arva irons. In an article published in this Journal, for April, 1875, giving an account of a spectroscopic examination of the gases from these bodies, it was stated that the volumes were as follows: Tennessee, 4·69; Texas, 4·75; Arva, 44+, whereas the volumes as determined in the subsequent investigations by actual measurement were 3·17, 1·29, and 47·13, respectively, as given in the table. The discrepancy is due to the fact that the former numbers were calculated from the change in the reading of the gauge of the air-pump on evolution of the gas, and were not corrected for the small amount of water vapor present. Where the quantity of gas was small the error from this source was considerable, and the result would have only the value of a rough estimate. In the case of the Arva iron, where the volume of the gas was much larger, the inaccuracy was not serious, and the volume corresponds much more nearly with the true result as obtained from measurement. In the later determination of the volume of gas from the Texas iron, moreover, the metal was in rather coarse fragments, and the evolution of gas from it was not as complete as in the previous case. That the amount of gas obtainable from this iron

* Pogg. Ann. 146, p. 297. † Comptes Rendus, lxxiv, 1545.

should approximate to that obtained from the Tennessee specimen, if the trial were made with finely pulverized metal, is clearly indicated by the results of the earlier experiments.

The necessity for the precautions mentioned in the previous paper respecting the degree of heat employed and the time of its application, was well shown in the repetition of the experiments with the Iowa meteorite. The reducing action of the metallic iron upon the carbon di-oxide, though not very apparent at comparatively moderate temperatures, becomes considerable as the temperature rises, and in some of the experiments where the heat was carried nearly to redness and prolonged beyond what was necessary for the evolution of the larger part of the gas, it was found that the amount of carbonic oxide was very variable, in one instance reaching to 12 or 13 per cent. This explains also the larger amount of this gas obtained in the preliminary examination of last year where the analysis gave 14 per cent, as no special attention was at that time given to this source of error. It is also clearly shown by the following experiment with a portion of the Weston meteorite. After the gas had been driven off from this by a red heat, pure, dry carbon di-oxide was admitted into the pump, and the tube heated nearly to redness for about half an hour. On pumping out some of the gas and analyzing it, it was found that nearly twenty per cent of it had been converted into carbonic oxide. Although great care was taken in all the subsequent work to avoid this source of inaccuracy as completely as possible, the percentages of this gas obtained at the higher temperatures are less certainly to be depended upon than the others. The amount of marsh-gas obtained also shows a certain correspondence with that of the carbonic oxide, as if, possibly, in the reaction by which the carbon di-oxide was broken up by the iron, a portion of the carbon combined with the hydrogen present to form marsh-gas, a supposition which is not without warrant from the conclusions of other observers.* But though some degree of uncertainty may attach to the numbers given for the higher temperatures, the fact that, with all the precautions observed in the experiments, the gases were found to be present in small quantities even at the lowest temperatures at which examination was made, renders it probable that the results are not far from the truth, and that carbonic oxide and marsh-gas are really to be reckoned among the gaseous contents of the stony meteorites, and that the same cause which produced the one in greater or less quantity had a similar effect upon the other.

Among the questions discussed in the previous paper, was the manner of the occurrence of the carbon di-oxide. This has

* Watts's Dict. of Chem.

been subjected to further examination, with the result of modifying somewhat the conclusions there arrived at. That it has been derived from the atmosphere by absorption subsequently to the fall of the body is improbable, for not only did the re-examination of the Iowa meteorite show a loss rather than gain with the lapse of time, but also there would seem to be little reason for a selective action of the mass, which would enable it to take up this gas in preference to the other atmospheric constituents, unless it were the fact of the feebly acid character of the carbon di-oxide, as in the presence of, or combined with, water. But in this case the carbonates formed by combination with the oxides present in meteoric masses, would be very stable compounds, and quite incapable of decomposition at the low temperatures employed.

The explanation was suggested in the earlier papers that the gas was condensed upon the finer particles of the metallic iron, as well as absorbed within it. With a view to test the correctness of this supposition, a special set of experiments was undertaken. A quantity of the substance of the Iowa meteorite was reduced to fine powder, and the iron extracted from it with a magnet, and kept by itself. The grains of iron were then rubbed repeatedly in an agate mortar to free them as completely as possible from the adhering stone, from which they were separated as before, the residue of the powder being added to that left by the first operations. The material was thus divided into two portions, one of which consisted chiefly of the stony matter, the other principally of the iron. For a third portion pieces of the meteorite were simply broken into small fragments, and not pulverized. Each portion was placed in a clean tube, and in its turn attached to the pump for examination, care being taken to subject each, as nearly as was possible, to the same degree of heat, and for the same length of time. The highest temperature employed was below that of red heat. The following were the results obtained:

	CO_2 and CO.	H.	N.		Volumes.
Powder,	66·96	30·96	2·08	0·97	1·48
Iron,	38·72	59·38	1·90	0·51	
Fragments,	48·07	50·93	1·00		1·87

Although, from the nature of the case, no very precise result could be expected from this mode of experiment, inasmuch as it was impossible either to separate the iron entirely from the mineral portion, or to free the iron completely from the stony matrix, the numbers above given indicate clearly that the stony portion yields a considerable portion of the gas given off at the temperature employed, and that this contains a larger proportion of the carbon oxides than that obtained from the iron, which, on the other hand, is richer in hydrogen. The product

of the stony fragments is, in its composition, approximately a mean between the two others, as was to be expected, but it will be seen that the volume obtained was somewhat larger, showing that a portion of the gas was lost in the process of pulverization. These facts would seem to indicate that, while a portion of the gas may be condensed upon the fine particles of the iron as at first conjectured, a large part of the carbon di-oxide, and possibly also of the water, carbonic oxide, and other gases, is mechanically imprisoned in the substance of the meteorite. Now Mr. Sorby has shown* that the meteorites of Aussun and Parnallee, when examined in thin sections under the microscope, contain numerous small cavities filled with gas, similar to those which have been observed in many terrestrial minerals. It will be noticed that the Parnallee meteorite was one of those examined by the writer, and found to yield 2·63 volumes of gas on the application of heat.

The occurrence of carbon di-oxide in cavities of minerals, under a pressure so great as to cause it to be in the liquid condition, as also associated with water, has been often observed, and has been quite recently proved in an ingenious and satisfactory manner, by Mr. Hartley,† for a large number of different minerals. Similar gas-cavities have been shown also to exist in many eruptive or volcanic rocks, for examples of which we need only to refer to Mr. Sorby's and Mr. J. C. Ward's papers in the Quarterly Journal of the Geological Society, and to other memoirs published elsewhere. The actual extraction and chemical examination of the gaseous contents of these bodies appears to have attracted little attention thus far, though they might lead to results of great interest and importance. Some incomplete experiments by the writer may be mentioned here, as illustrations, though but little weight is attached to them as quantitative determinations. A quantity of pulverized trap-rock was subjected to a heat which was raised to incipient redness, the examination being conducted by the same method as that employed upon the meteorites. The mineral gave off about three-fourths of its volume of mixed gases, which were found to contain about 13 per cent of carbon di-oxide, the residue being chiefly hydrogen. Another specimen of trap containing small nodules of anorthite, was examined, at the request of Mr. G. W. Hawes, who had observed gas-cavities in a thin section of the mineral prepared for microscopic examination. This gave off somewhat more than its own volume of gas, which was found to contain some 24 per cent of carbon di-oxide. The gas in these cases was not given off as readily as from the meteorites, and was evolved rather suddenly as a temperature approaching red-heat was reached. If it should appear improbable that the large

* Proc. Royal Soc., June 16, 1864.
† Chem. News, June 9, 1876, p. 237.

amount of gas contained in the Kold Bokkeveld specimen could be retained in this way, it may be suggested that the amorphous carbon contained in it is a substance peculiarly fitted to absorb and retain large volumes of gas. These results would seem rather to assimilate the stony meteorites to terrestrial rocks of volcanic origin, than to place them in a different category, and to strengthen the evidence that they are themselves the product of igneous action, though modified profoundly in some respects in their structure, by the influence of other forces, and the circumstances of their formation. The supposition of the imprisonment of the gas in the stony substance would also serve to explain why the water, which can not be separated by a temperature of 100°, continues to be given off even at the highest temperatures employed, as has often been observed in experiments with meteorites.

It has been pointed out by astronomers that on arranging the mean distances of the asteroids in a series, there are found to be certain gaps in the list, as if some members were wanting. Now it is further found that the periodic times of these missing bodies stand in a simple relation to the time of Jupiter's revolution, and in such a way that his continued action upon them would accumulate the perturbative effects, tending to throw their orbits into eccentric forms. Such of the bodies as were caused to move in very narrow orbits, with shortened period, would be exposed to very great vicissitudes of temperature, and during the part of the orbit near the sun not only would the change of temperature be comparatively rapid but the actual degree of temperature reached would be very considerable, especially considering the fact that these bodies are of too small mass to permit them to retain an atmosphere of any appreciable amount. It is not difficult to see that these great changes of temperature in a mass of considerable absorptive and low conducting power must give rise to powerful stresses, and that under the intense action of the sun near the perihelion the action may be sufficiently energetic to cause the splitting up of the bodies themselves. The disruptive action requisite to separate a mass from the principal body entirely, and so as not to return, would be less as the mass of the body is smaller, and would, for a mass no larger than some of the asteroids, be quite within the range of possibility. The body would thus be subject to a continuous process of disintegration in its successive revolutions, and must end in being broken up into a swarm of fragments which would gradually be distributed over the entire orbit. Such an action appears to be really going on in some of the comets, and moreover the orbits of several of them are coincident with those of great meteoric streams, in which the process of disaggregation has already gone very far. Now, of the comets of short period a considerable number are grouped

with their orbits in such a relation to that of Jupiter as to suggest the possibility of their derivation from the asteroids. Similar considerations also apply to the group of comets associated with the orbit of Neptune, the existence of which suggests the question whether there may not be another group of asteroids, exterior to this body, yet remaining to be discovered. But without assuming the asteroidal origin of these comets, the effects of solar heat just described may be safely predicated of them, as well as of other comets or meteoric masses revolving in excentric orbits.

This process of disintegration, in the earlier stages of the history of one of these bodies, would constantly present fresh surfaces for the action of the sun's rays, which must cause the evolution of large volumes of gas, and the rifts and fissures produced by the cooling at aphelion would allow the gas contained in the interior of the body to stream off under comparatively little increase of temperature. This gaseous matter, expanding into empty space and streaming off, forms the tail of the comet, which is driven away from the sun's direction by some repellant force possibly due to electrical action. That the amount of gaseous substance furnished by such a body should be sufficient to form a luminous train of the immense extent often observed in comets need not appear incredible, if we reflect that of a substance like the Kold Bokkeveld meteorite every cubic mile would furnish thirty cubic miles of gas at the pressure of the terrestrial atmosphere, and that this in space would be speedily expanded to enormous dimensions, before it would cease to be capable of transmitting electric discharges, or to be visible by reflected sunlight. As the masses of some of the comets have approached planetary dimensions there is no difficulty in accounting for the enormous trains some of them have exhibited. Moreover there is reason for believing that the meteorites which reach the earth are the spent fragments, as it were, which have already parted with a considerable portion of their gaseous constituents by the long continued action of the sun as above described, so that the amount of gas contained in some of these celestial bodies may be even much larger than that we observe in actual meteorites. We may also take into account the not inconsiderable amount of water contained in these bodies, to say nothing of the volatile carbonaceous matters which are present in some of them.

Besides the relations mentioned above, may be cited the near correspondence of the average density of the stony meteorites with the calculated density of the asteroids, which, though possibly accidental, is certainly suggestive of a community or similarity of origin.

Additional and most striking testimony to the real connection

of the meteorites and comets is afforded by the close resemblance of the spectrum of the gas obtained from the stony meteorites to the spectra of those comets which have thus far been observed.

Many observations respecting this point were made upon the gases collected from the various meteorites examined, in the course of the investigations which have been described. Vacuum-tubes of the form usually employed in spectroscopic work were attached to the pump and filled by the meteoritic gases as they were evolved. After the latter had been pumped out for the most part into the collecting tube, a freezing mixture was applied to one of the tubes of the pump and allowed to remain until the watery vapor was condensed, thus rendering the gas in the vacuum-tube very nearly free from moisture. As the vapor of mercury is always shown by spectroscopic examination to be present in tubes filled in this way by the use of a mercury-pump, small pellets of clean gold foil were previously placed in the tubes, in order to absorb the metal. This proved to be quite effectual in some cases, in others only partially so. The tubes, having now been sufficiently exhausted by the continued action of the pump, were removed, sealed, marked, and preserved for examination.

On passing the discharge of an induction coil through these tubes when placed before the slit of a spectroscope, a spectrum is seen, which varies with the conditions. That from the capillary portion of the tube shows the hydrogen lines brilliantly, together with the bands due to carbon compounds. In the wide part, however, the hydrogen lines are entirely absent, only the carbon bands being visible. When the illumination is sufficiently strong these are five in number, all sharp at the least refrangible edge, and fading gradually away at the other. When the slit is narrowed, or the tube removed to a greater distance so as to diminish the intensity of the light, only three remain visible, namely, one beginning in the yellowish-green, one in the green, and another in the greenish-blue. Of these the middle one is by far the brightest, and when the light is very much enfeebled remains visible after the others have disappeared. Of the latter, the one in the greenish-blue is brighter than the other. A resemblance to the spectra of the comets is apparent at a glance, not only in the positions, but also in the form and relative brightness of the bands. A closer comparison however shows a marked difference in their breadth, the cometary bands, as represented by various observers, covering a considerably greater space. There appeared also to be a want of exact coincidence in their positions. For the first two the difference was not greater than the discrepancies of the results given for different comets, and the bands agreed very well with some of the observations. The third band showed a greater divergence.

As the greater breadth of the cometary bands indicates a density of the cometic gases greater than that in the tubes examined, an experiment was made, as follows, for the purpose of observing the effect of increasing the density of the gas. A glass tube, having an internal caliber of about one centimeter and some twenty centimeters in length, was closed at one end, and through the sides were inserted two platinum wires, at points near the middle of the tube, the inner ends of the wires being in its axis and separated by an interval of about one centimeter. Small fragments of the Kold Bokkeveld meteorite were dropped into the tube and shaken down into the closed end. The upper end was now drawn out to a narrow neck, and the whole attached to the pump. After exhausting the air, the neck was sealed, the tube withdrawn, and supported in a vertical position so that the interval between the wires was before the slit of the spectroscope, the end containing the meteorite being below. By means of wires connecting the platinum points with an induction coil, sparks were passed across the interval, and when the lower end of the tube was gently heated, the characteristic spectrum of the gas evolved became visible. At first it was very similar to that which had been observed previously, but as the heat was increased, and the pressure of the gas became greater, the bands were seen to widen out, until they at length fully equalled in breadth those of the comets, and finally they showed a tendency to run together. In the order of their relative intensity there was no appreciable change.

The slight disagreement in the positions of the first two bands with the reported observations of cometary spectra is readily explained when we consider that for the latter a rather wide slit is necessary in order that they may be distinctly seen. If the object viewed were a sharp fine line, the effect of opening the slit would be merely to increase its breadth without affecting the sharpness of the edges. It is easy to see however that a band, though with a narrow slit the edge were sharp and brighter than the other parts, would have its point of maximum brightness removed toward the middle of its breadth, and the farther as the opening were greater. The effect of this would be that a faint band would appear hazy at the edge, and the tendency would be to displace its apparent position towards the brightest point. Further, the measured position of the edge would be affected by the change of place of the movable edge of the slit. A simple experiment with the tube showed that the alterations from these two sources were sufficient to account for the apparent want of agreement in the positions of the bands, and also to explain some of the discrepancies in the results of different observers, as to the posi-

tion of the cometary bands, especially when regard is paid to the faintness of the light and the consequent difficulty of precise determination. Measurements of the first two bands, with the slit rather wide and the intensity of the light sufficiently diminished, were found to coincide very satisfactorily with the best recorded observations upon the corresponding bands in the spectra of comets. For the third band the result was less satisfactory, as it appears to be somewhat less refrangible than its cometary analogue, as determined by the majority of observations of the latter, though it agrees very well with some of them. Not improbably, however, the hydrocarbons existing in small quantities in some of the meteorites may be present in the comets in sufficient amount to modify their spectra somewhat.

Yale College, July 28, 1876.

ART. XXII.—*Schœnbein's Test for Nitrates;* by F. H. STORER, Professor of Agricultural Chemistry in Harvard University.

IN his important paper on the Behavior of Ozone towards Water and Nitrogen, Carius* remarks incidentally that he has not found the iodo-starch test for nitrates (employed in conjunction with zinc, as the reducing agent) a specially delicate one.

It is obvious that this test for nitrates cannot in the nature of things compare in delicacy with the similar test for nitrites, where the iodo-starch is added directly to the suspected liquid, after mere acidulation. A much smaller quantity of nitrite than of nitrate can always be detected by the above mentioned test, since the zinc, or other reducing agent, which is made to act upon the nitrate in order that the iodo-starch reaction may occur, does not in any case change the whole of the nitrate into a nitrite and no other nitrogenous product. The zinc may fail, upon the one hand, to reduce the whole of the nitrate, while upon the other its action may go too far, so that a part of the nitrite, formed at first, through reduction of the nitrate, may be reduced in its turn and removed from the field of action. Some of the nitrate is always changed, withal, to an ammonium salt and so destroyed in so far as the power of reacting upon iodo-starch is concerned.

These considerations have often been urged, and they are undoubtedly familiar to most chemists. But in the lack of a better, the iodo-starch test for nitrates has come into very general use and has been held in high estimation. The remark of Carius must have struck scores of chemists, as it did myself,

* Annalen der Chemie, 1874. clxxiv, 14, note.

as extraordinary and hardly credible. It was neither consistent with Schœnbein's statement as to the delicacy of the test nor with the reputation which the test had acquired. I have thus been led to examine the matter somewhat attentively and to subject the test anew to critical study. It appears from this examination that the lack of delicacy observed by Carius was due to the kind of manipulation employed by him, and that while his statement is doubtless literally correct it fails to convey a just idea of the much higher degree of delicacy which is readily obtainable by applying the test in a somewhat different way.

Two methods of using the test were described by Schœnbein,* viz: 1st, To add dilute sulphuric acid and iodo-starch paste directly to the nitrate solution and to stir the mixture with a zinc rod; or, 2d, and better, as we must infer from Schœnbein's statement, to reduce the neutral solution of the nitrate in the first place, by means of zinc or cadmium, thereafter to acidulate it with dilute sulphuric acid, and finally to add the iodo-starch paste. Both of these modifications have come into general use, but the second has been applied perhaps even more frequently than the first in cases where very small amounts of nitrates were to be sought for. It is in fact more delicate than the first method. Carius, however, in the experiments above referred to, employed the first modification and not the second.

For my own part, I find that the chief objection to the iodo-starch test for nitrates is by no means a lack of delicacy. The fatal defect of the test, as hitherto applied, is to be found in the fact that mere water, which is absolutely free from any contamination of nitrates or nitrites, on being treated with zinc or cadmium, as if to test it for a nitrate, will react upon iodo-starch precisely as if a trace of some nitrate had been dissolved in the water.

The explanation of this behavior is not far to seek. The coloration of the iodo-starch is caused by peroxide of hydrogen which has been formed in the water by the action of the metal, according to the familiar experiment of Schœnbein† in which peroxide of hydrogen is prepared by shaking zinc-amalgam in water and air.‡

* See for example, his paper in Fresenius's Zeitschrift analyt. Chemie, 1862, i, pp. 14, 15.

† Poggendorff's Annalen, 1861, cxii, 288.

‡ Schœnbein has himself shown (Journal für prakt. Chemie, 1861, lxxxiv, 206) that peroxide of hydrogen is formed simultaneously with a nitrite, when the aqueous solution of a nitrate is treated with zinc or cadmium, as a preliminary to the application of the iodo-starch test, but he seems to have completely overlooked the fact that the presence of the peroxide would preclude the application of his test for nitrites, in cases where the solution to be examined contained only a small quantity of the nitrate.

The amount of peroxide of hydrogen that is formed in the limited volume of liquid used, and under the conditions which ordinarily obtain when testing for a nitrate, is undoubtedly very small, but it is nevertheless sufficient to give a perfectly distinct reaction with acidulated iodo-zinc-starch solution. This reaction is far too strong to admit of its being neglected, subtracted, or allowed for, when searching for traces of nitrates. Hence it happens, that in highly dilute solutions of nitrate of potash it is impossible to detect the nitrate by means of iodo-starch as ordinarily applied, not because the products of the reduction of the nitrate by zinc, or the like, cease to act upon the iodo-starch, but because the reaction produced by these products is identical with that of the peroxide of hydrogen that is formed simultaneously with them, and which would be formed just as well in pure water totally devoid of nitrates.

Whenever the degree of coloration of the iodo-starch obtained, in testing for a nitrate according to Schœnbein's method, is less intense than the tint obtainable from 0·0001 gram N_2O_5 (=0·000187 gram KNO_3) in 50 c.c. water it is difficult to decide whether the coloration may not be wholly due to peroxide of hydrogen. It is easy, at all events, to obtain as much peroxide of hydrogen by boiling cadmium, zinc or amalgamated zinc with mere water, as will give a reaction with acidulated iodo-zinc-starch equal to that obtainable from 0·00005 gram N_2O_5 or perhaps even more. The following experiments will illustrate this point.

A. To 50 c.c. of pure water 0·00005 gram N_2O_5 (in the form of 0·0000936 gram of nitrate of potash) was added, the mixture was boiled five minutes with a piece of cadmium, in a small flask, then cooled, transferred to a porcelain capsule, acidulated and tested with iodo-zinc-starch.

B. The same experiment was repeated with pure water to which no nitrate had been added.

C. Same as A., with the exception that zinc was used instead of cadmium.

D. Same as B., with the exception that zinc was used instead of cadmium.

The four capsules were placed side by side under a darkened bell glass and left to stand over night. On examination it appeared that while the contents of capsules B, C and D seemed to be of one and the same depth of color, the contents of capsule A were distinctly lighter colored than those of either of the other dishes. These experiments were simultaneous, and care was taken that they should be strictly comparable one with another. Each experiment was conducted as if a nitrate were being tested for. Equal surfaces of metal, as nearly as might be, were exposed to the action of the liquids, in each instance.

Repetitions of these tests gave similar or analogous results Sometimes the contents of one capsule in the series would be more or less strongly colored than the rest and at other times another, but everything went to show that by this method of testing traces of nitrates cannot be distinguished from the peroxide of hydrogen that is naturally formed in the liquid under examination. So too, when amalgamated zinc was used instead of the simple zinc or cadmium. It is true, as Schœnbein * has said, that water which contains only $\frac{1}{1000000}$ of nitrate of potash will color iodo-starch blue, after having been shaken or boiled with bits of amalgamated zinc, filtered, and acidulated with sulphuric acid; but since water that is absolutely free from nitrates will do almost precisely the same thing when similarly treated, the statement is of no value either as regards the delicacy of the test, or the limit of its applicability.

Proof that the cause of the reaction in the water free from nitrates is really due to the presence of peroxide of hydrogen is readily obtained on testing the neutral liquid for that substance, with a drop or two of a weak solution of ferrous sulphate † and the solution of iodo-zinc-starch. The characteristic blue coloration of the iodo-starch will quickly appear when pure water that has been boiled with cadmium or with zinc is subjected to this test, while no reaction is obtained, even after the lapse of many hours, when pure water that has not been in contact with a metal is similarly treated.

With pure water these results are constant and invariable, but it is noteworthy that on testing in this way, samples of water taken from wells, and of rain water taken respectively from a brick and from a leaden cistern, no reaction for peroxide of hydrogen was obtained after simple boiling for five minutes with the cadmium, though on boiling with cadmium and then leaving the liquid to stand upon the metal for twenty-four hours a reaction for the peroxide was finally obtained with the rain water. So too when the pure water was tested in a somewhat different way by mixing it directly with the solutions of iodo-zinc-starch and sulphate of iron and ammonia, and placing a piece of cadmium in the mixture, the blue coloration soon appeared, while no such coloration was observed when samples of rain or well water were tested in this way; far from becoming blue, the liquids soon acquired a rusty color, as if from oxidation of the iron salt.

Care was taken to control the peroxide reactions by apply-

* Zeitschrift analyt. Chemie, 1862, i, 15.

† Or instead of simple ferrous sulphate, the double sulphate of protoxide of iron and ammonia may be used with advantage, as was suggested by Struve, Fresenius's Zeitschrift analyt. Chemie, 1869, viii, 319. Most of the tests described in the text were made with this double salt. Two or three drops of a $\frac{1}{100}$ normal solution of it were ordinarily used.

ing the test (ammonium-ferrous sulphate and iodo-zinc-starch) to acidulated water, that had not been in contact with cadmium or zinc, to acidulated and to neutral solutions of pure nitrate of potash, to neutral solutions of nitrite of soda, all made with pure water, and to the distillate from a solution of nitrite of soda that had been boiled with dilute sulphuric acid. But no trace of blue coloration was observed in either instance.

Corroborative evidence of the presence of peroxide of hydrogen in the water that had been boiled with cadmium was obtained as follows: Two portions, each of 100 c.c., of pure water, were taken. To one portion two hundredths of a milligram of nitrous acid was added, in the form of nitrite of soda, together with 2 c.c. of dilute sulphuric acid (1:4) and the mixture was boiled for ten minutes in order to expel the nitrous acid. The other portion was boiled with cadmium, as if it were to be tested for a nitrate, the cadmium was removed, the liquid was mixed with 2 c.c. of the dilute acid and then boiled for ten minutes. Each portion was finally tested, when cold, with iodo-zinc-starch. The second portion, viz: the one to which no nitrite had been added, speedily gave a reaction, but the first portion did not. After standing twelve hours in the dark, the first portion remained colorless, while the second portion was distinctly blue. In a word, the nitrous acid known to have been present in the first portion had been completely expelled by the boiling, while much of the peroxide of hydrogen in the second portion had remained intact.

The fact that highly dilute aqueous solutions of peroxide of hydrogen suffer but little decomposition at the temperature of boiling has often been insisted upon;* but less attention seems to have been paid to the equally important fact † that some of the peroxide goes forward, as such, with the vapor of water, and may be detected in the distillate. This volatility of the peroxide is a point of no little significance for the analyst, since it makes it very much more difficult than would otherwise be the case to detect traces of nitrites in solutions suspected to contain them, as well as the peroxide. Contrary to the opinion expressed by Plugge ‡ it would be altogether useless in delicate experiments to apply, in the presence of peroxide of hydrogen, that method of testing for nitrites which depends upon the volatility of nitrous acid, viz: the distillation of the nitrite solution with a dilute acid and subsequent testing, with iodo-starch plus acid, for nitrous acid in the distillate. The following experiments will illustrate the importance of this consideration. Two portions of pure water, each of 250 c.c., were taken, and one was distilled directly with

* Compare Gmelin-Kraut's Handbuch der Chemie, 1872, i (2te Abth.), p. 58.

† First recognized, I believe, by Schœnbein. See Will's Jahresbericht, 1866, p. 105.

‡ Fresenius's Zeitschrift analyt. Chemie, 1875, xiv, 141.

acetic acid while the other was boiled with cadmium for five minutes and thereafter distilled with acetic acid, pains being taken to make the two experiments alike in all other respects. The first 50 c.c. of distillate were collected in each instance and tested with iodo-zinc starch, after acidulation. No reaction was obtained in the distillate from the mere water and acetic acid, while the distillate from the water that had been boiled upon cadmium became colored in less than half an hour. Repetitions of this experiment gave similar results.

That only a part of the peroxide goes forward with the steam will be seen from the following trials:—Two separate 250 c.c. portions of pure water that had just been distilled off from a flask containing a mixture of zinc and spongy copper were boiled with cadmium, and a part of each of the liquids was tested directly with iodo-zinc starch plus acid, while the remainders were distilled with acetic acid and the first 50 c.c. of distillate was subjected to the test in each instance. In both trials the portions tested directly gave a stronger coloration than was obtained in either of the distillates. In order to be sure that the acetic acid had no improper influence on these reactions, several portions of pure water were distilled with the acetic acid for a time, a fresh portion of the acetic acid was then added and the next 50 c.c. of distillate was tested with iodo-zinc starch plus acid, but no reactions were obtained, although the mixtures were allowed to stand twenty-four hours after the application of the test.

It may be mentioned in this connection that the tendency of peroxide of hydrogen to be transported with the vapor of water may perhaps afford the true explanation of the cause of the presence of the peroxide in some of the solutions examined by Meissner in his Untersuchungen über Sauerstoff, Hannover, 1863, pp. 94–110. Such transportation of the peroxide may account moreover for the presence of this substance in the outer or water tube of Schœnbein's and Meissner's (op. cit., p. 74) earlier experiments on the making of peroxide of hydrogen from peroxide of barium and sulphuric acid, without need of supposing that the "antozone" of these chemists had any part in the reaction.

With regard to the delicacy of the iodo-starch test for nitrates, supposing there were no interference from peroxide of hydrogen, it appears, as has been stated above, that that method of procedure in which the nitrate is reduced by itself, as a separate, preliminary step, before the acidulation of the liquor or the addition of the iodo-starch, is decidedly preferable to the other system of adding the iodo-starch, the acid, and the reducing agent all at once to the nitrate solution. As Goppelsrœder*

* Poggendorff's Annalen, 1862, cxv, 128.

has remarked, it seems to be immaterial whether the nitrate solution be boiled for a few moments with the cadmium or zinc, or left to stand for some hours in the cold in contact with one of these metals; though the boiling will usually be found more convenient in practice.

It has been customary hitherto, in this laboratory, to proceed as follows, when testing for nitrates by Schœnbein's process: 100 c. c. of the suspected liquid were put in a small glass flask, together with bits of metallic cadmium and boiled for five minutes. When the liquid had become cold half of it was transferred to a small porcelain dish, one c. c. of dilute sulphuric acid* was added to it, and finally, two c. c. of iodo-zinc-starch solution.† The capsule, with its contents, was then placed under a darkened bell-glass and examined at stated intervals. Tested in this way, a solution of nitrate of potash, containing

* The dilute sulphuric acid is prepared by mixing one volume of oil of vitriol with three volumes of pure water, boiling the mixture for an hour, and finally adding enough pure water to replace that which has evaporated.

† The solution of iodo-zinc-starch is prepared as follows, after Kubel-Tiemann, "Anleitung zur Untersuchung von Wasser," Braunschweig, 1874, p. 140: Rub 4 grams of starch in a porcelain mortar with a little water, and pour the smooth, milky liquid, little by little, into a boiling solution of 20 grams pure commercial chloride of zinc in 100 c. c. of distilled water. Continue to boil the mixture until as much of the starch as possible has dissolved, and the liquid has become almost clear, taking care meanwhile to replace the water that evaporates. Dilute with distilled water; add 2 grams of pure, dry, commercial iodide of zinc; bring the volume of the liquid to a litre, and pour it into a tall cylinder, to settle. After several days, decant the clear liquid and keep it in the dark in well-closed bottles.

Pure water is obtained as follows: Enough crystallized permanganate of potash is dissolved in rain-water to color the liquid strongly; the mixture is left to stand for 24 hours, and then transferred to a copper still. A lump of lime is added and the mixture is distilled slowly, the first fractions of distillate being rejected. The rest of the distillate is redistilled in a glass flask, upon lime, and the new distillate is rejected until it ceases to show ammonia when tested with Nessler's reagent. Such water is free from ammonia and from nitrates, and when tested for nitrites with iodo-zinc-starch, plus acid, it will not show any trace of coloration at the end of an hour, and will seldom show any appreciable tinge of color when the mixture is left to stand over night, though on standing for 24 hours a faint shade of color will usually appear. I have commonly attributed this tendency to give a reaction to the presence of an infinitesimal trace of nitrite, but it is not impossible that it may be due to peroxide of hydrogen that has been formed by means of the copper of the still. It would undoubtedly be better, when possible, to perform all the distillations in glass vessels. However that may be, such water is abundantly pure enough for the purposes of this research. For cases where absolute purity is essential, water that will not give any reaction for nitrites may be prepared, by acidulating with acid sulphate of soda the pure water obtained as above (from glass vessels) and redistilling it in a glass flask. Free nitrous acid being readily volatile will go forward in the first portions of distillate from the acidulated water, so that, by rejecting a considerable fraction of the distillate at first and saving the water that comes over later, it is no very difficult matter to obtain water that is perfectly free from all three of the nitrogen compounds now in question as well as from peroxide of hydrogen.

Most well waters it should be said, are, if anything, rather better than rain-water for preparing a pure product.

By making the mixture of permanganate and water alkaline with lime instead of a caustic alkali, the nitrous compounds which almost always contaminate the latter are avoided.

0·0005 grm. N_2O_5 in 50 c. c. water, gave an immediate coloration on being mixed with iodo-zinc-starch plus acid, after having been boiled for five minutes upon cadmium; with a solution containing 0·0002 grm. N_2O_5 the blue coloration appeared about 5 minutes after the addition of the iodo-starch, and with a solution containing 0·0001 grm. N_2O_5 the color began to appear in about 8 minutes. The last named quantity indicates very nearly the limit of applicability of the test, since the degree of coloration derivable from an amount of the nitrate any smaller than this, could hardly be distinguished from that due to the peroxide of hydrogen that is obtained on boiling pure water upon cadmium or zinc. It is true that the coloration caused by the products of the reduction of a nitrate generally appears rather more speedily than the coloration produced by peroxide of hydrogen, but since the reaction of the peroxide often begins to show ten or fifteen minutes after the addition of the iodo-zinc-starch and acid, and sometimes even sooner, no dependence can be placed upon mere rapidity in the appearance of the coloration, as a means of distinguishing the nitrate from the peroxide. In case the mixtures are left to stand over night, or for a number of hours, after the iodo-starch has been added, this seeming advantage in favor of the nitrate solutions disappears, for after long standing the coloration due to peroxide of hydrogen is often as deep as that obtained from 0·00005 grm. N_2O_5, and the difference between this tint and that obtained from 0·0001 is by no means large enough to permit of distinguishing the one from the other with any certainty.

Results very different from the foregoing were obtained when 50 c.c. of the pure nitrate solution, mixed directly with two drops of the dilute acid and 2 c.c. of the iodo-zinc-starch solution, were left to stand in contact with a rod of zinc, according to the method employed by Carius.* On proceeding in this way, a solution containing 0·01 grm. of N_2O_5 (=0·01872 grm. KNO_3), in 50 c.c. of water gave a reaction almost immediately when the zinc was added; and a solution containing 0·005 grm. N_2O_5 (=0·00936 grm. KNO_3) began to show a blue coloration at the lower end of the zinc rod in a few minutes, while in a solution containing 0·002 grm. N_2O_5 (=0·00374 grm. KNO_3) no coloration could be perceived even after the lapse of two hours, though the liquid was examined at frequent intervals. On repeating this trial with 0·002 grm. N_2O_5 a similar result was obtained. 0·003 grm. N_2O_5 (=0·005616 grm. KNO_3) in 50 c.c. water gave a very slight coloration at the lower end of the zinc rod after a comparatively short time. Trials similar to the above, in which amalgamated zinc was used instead of simple zinc, gave

* Annalen der Chemie, 1874, clxxiv, 14.

no better results, but rather worse on the whole. Rods of cadmium appeared to be somewhat preferable to those of zinc, though not much.

It will be observed that the results of these tests are even less favorable than those obtained by Carius, since this chemist puts the limit of delicacy at 0·0015 grm. KNO_3 in 50 c.c. water. The following experiments moreover go to show that when the test is used in this manner the presence of trifling impurities in the solution to be examined may interfere with the reaction very decidedly and render the negative indications of the test untrustworthy even at the comparatively low degree of delicacy above mentioned. Thus, on repeating some of the foregoing trials and using rain-water to dissolve the nitrate, instead of the pure water previously used (see page 182, note) less favorable results were obtained. A solution of the nitrate equal to 0·005 grm N_2O_5, in 50 c.c. cistern water gave no reaction with the iodo-zinc-starch in the course of an hour. On repeating the trial with cistern-water that had just been boiled, a slight reaction was obtained, but the blue color instead of increasing faded away after a time and disappeared. The proportion of acid employed to acidulate the mixture is not without influence upon the delicacy of the test, and it may well be that in order to the best results a larger amount of acid is required than was used in the foregoing trials. The small quantity of the acid actually taken was chosen in order to conform to Carius's injunction that "the addition of but little acid is a condition of success." But it appeared once on repeating the trial with the nitrate solution, in pure water, that contained 0·005 grm. N_2O_5 in 50 c.c., that while no coloration of the iodo-starch had appeared after some time so long as only two drops of sulphuric acid had been added, the reaction soon set in on the addition of two more drops of the acid.

The defect of the usual method of testing for nitrates having been made apparent, I have naturally endeavored to discover some better method of procedure which, while preserving all the delicacy of the test, should permit its general application. Casting about for some means of reducing nitrates to nitrites which should not at the same time occasion the formation of peroxide of hydrogen, I have finally hit upon the simple device of boiling the nitrate with metallic cadmium in water that is slightly acidulated, instead of operating with neutral solutions, as has hitherto been recommended. Contrary to what might have been inferred from what has been published hitherto, and from what is known of the action of acidulated water upon metals in the cold, no peroxide of hydrogen is formed when water slightly acidulated with sulphuric acid is boiled upon metallic cadmium; and since the reduction of

nitrates to nitrites by means of cadmium occurs readily in such boiling acidulated solutions it happens that the iodo-starch test can be employed in this way for the detection of nitrates without difficulty and with a high degree of certainty. The only special precautions to be taken are to test the boiled liquid with litmus paper in order to be sure of its acidity, and to guard against the loss of any nitrous acid by volatilization. This can readily be done by attaching to the small flask in which the nitrate is reduced a small inverted Liebig's condenser, through the sleeve of which a stream of cold water is made to flow. The following experiments will illustrate the delicacy of this new method of testing:

A. 0·0005 grm. N_2O_5, in the form of nitrate of potash, was boiled for five minutes upon metallic cadmium in 50 c.c. of pure water to which two drops of the dilute sulphuric acid, of p. 182, had been added. On testing with iodo-zinc-starch plus acid a strong reaction was obtained, almost immediately.

B. 0·0002 grm. N_2O_5 similarly treated gave a reaction in about five minutes.

C. 0·0001 grm. N_2O_5 gave a reaction in rather less than fifteen minutes.

D. 50 c.c. of pure water acidulated with two drops of the dilute sulphuric acid, and boiled upon cadmium, without any addition of a nitrate, gave no reaction with iodo-zinc-starch plus acid, not even on standing over night.

Repetitions of these trials gave results that were identical with the foregoing.

E. 0·00005 grm. N_2O_5 in 50 c.c. of pure water was tested, as above, in comparison with pure water devoid of nitrate. At the end of half an hour the solution that had contained the nitrate gave a rather strong coloration with the iodo-starch, while the pure water remained perfectly colorless.

F. 0·00001 grm. N_2O_5 in 50 c.c. water was tested as above. But no reaction was obtained with the iodo-starch, not even after the lapse of 36 hours.

G. In order to determine whether metallic cadmium in acidulated water actually destroys peroxide of hydrogen at the temperature of boiling, 100 c.c. of pure water were boiled upon cadmium and left to stand in contact with the metal over night; the water thus charged with peroxide was divided into two equal portions, one of which was tested directly with iodo-starch plus acid, while the other was acidulated with two drops of dilute sulphuric acid, again boiled upon cadmium and then tested. A strong reaction was obtained in the portion tested directly, but no reaction was obtained from the acidulated portion until after the lapse of two hours, and then the coloration was but slight. In repeating this experiment, 100 c. c. of pure

water were boiled upon cadmium for five minutes; 50 c. c. of the water were then poured off to be tested, while two drops of dilute sulphuric acid were added to the flask, and the acidulated liquid was again boiled for five minutes with the cadmium. On decanting and testing the acidulated liquid with iodo-starch, it gave no coloration, not even after the mixture had stood over night, while on testing the portion that had been boiled without acid it gave a strong coloration in due course.

H. To see if hydrogen alone would so quickly destroy the peroxide, a stream of hydrogen gas was made to flow during five minutes through a solution of peroxide of hydrogen, prepared as above, that was kept at the temperature of boiling. But the liquid thus treated gave almost as strong a reaction with iodo-starch after the passage of the hydrogen as it had done before.

On trying whether some one of the more common metals might not perhaps be used in testing for nitrates by the new method, it appeared that neither of them is on the whole so well fitted for the purpose as cadmium. Thus on repeating the foregoing experiments, with zinc, amalgamated zinc, aluminum, and iron, it appeared that while no peroxide of hydrogen was formed on boiling acidulated water upon these metals, neither of them was so well fitted as cadmium to reduce nitrates to nitrites in acidulated solutions. From zinc and from amalgamated zinc, distinct reactions were obtained with solutions containing 0·0005 grm. N_2O_5 in 50 c.c. water, when the iodo-starch mixture was left to stand over night, though no coloration appeared until after the lapse of more than two hours; slight reactions were obtained also, after long standing, from solutions that contained 0·0001 grm. N_2O_5; but no reaction was obtained in a solution that contained 0·00005 grm. N_2O_5. From aluminum a slight coloration of the iodo-starch was obtained, after two hours standing, with a solution that contained 0·01 grm. N_2O_5 in 100 c.c. water, and a stronger reaction was got from a solution that contained more of the nitrate. From iron no reaction was obtained, in the course of two hours, with a solution containing 0·01 grm. N_2O_5 in 100 c.c. water, though with a considerably stronger solution a reaction was obtained. A solution containing 0·01 grm. N_2O_5 in 100 c.c. water boiled upon a mixture of iron and platinum gave a reaction almost immediately, but one containing 0·001 grm. N_2O_5 gave no reaction after having been boiled upon the mixed iron and platinum. No reaction was obtained with a solution containing 0·01 grm. N_2O_5 in 100 c.c. water after adding to it a small quantity of acidulated sulphate of silver and boiling the mixture upon iron.

Both lead and magnesium easily reduce nitrates to nitrites in

acidulated solutions, magnesium perhaps even more readily than cadmium, but neither of them would seem to be so good as cadmium for use in testing for nitrates since they form peroxide of hydrogen when boiled in water that is no more strongly acidulated than that just described. The trouble with both metals, but particularly with magnesium, seems to be that they combine with and consume the acid too rapidly so that the solution becomes neutral or well nigh neutral, and fit for the production of peroxide of hydrogen, before the boiling process is finished.

In experiments with lead it was found that a solution containing 0·0001 grm. N_2O_5 in 50 c.c. gave a decided reaction with iodo-starch in less than half an hour, and that a solution containing 0·00005 grm. N_2O_5 gave a distinct reaction in half an hour, though it was not quite as strong as the reaction obtained with cadmium under similar circumstances. 50 c.c. pure water plus two drops dilute sulphuric acid, boiled five minutes upon lead without the addition of any nitrate gave a slight reaction with iodo-starch and acid on standing over night; but on repeating the experiment with four drops of acid no reaction was obtained.

In experiments with magnesium it was found that nitrate solutions containing respectively 0·0001 and 0·00005 grm. N_2O_5 in 50 c.c. water gave reactions with acidulated iodo-starch within fifteen minutes; and that a solution containing 0·00001 grm. N_2O_5 plus four drops of acid gave a distinct reaction on standing over night. But 50 c.c. pure water plus two drops dilute sulphuric acid boiled five minutes upon magnesium without addition of any nitrate gave a slight reaction in the course of two hours, and on repeating the experiment, with four drops of acid a slight reaction was obtained on leaving the mixture to stand over night, though none was visible at the end of two hours. With silver, an acidulated solution containing 0·025 grm. N_2O_5 in 50 c.c. water gave a very slight reaction with iodo-starch in the course of two hours, while a weaker neutral solution, containing 0·01 grm. N_2O_5 in 100 c.c. water, that was boiled upon silver gave no reaction.

It is to be observed that in the foregoing set of experiments the solutions were acidulated in every instance before the boiling, and that an inverted condenser was always attached to the flask in order to prevent the escape of any nitrous acid.

Solutions containing 0·005 grm. N_2O_5 in 50 c.c. acidulated water, left in contact for eight hours or more in the cold with metallic aluminum, iron or zinc, and then tested with iodo-starch gave no reaction in the cases of iron and zinc, and only a slight coloration in the case of aluminum.

No reaction for peroxide of hydrogen was obtained in acid-

ulated water that had been boiled five minutes upon a mixture of pieces of tin and platinum, nor was any reaction obtained from an acidulated solution of nitrate of potash that had been similarly boiled.

Numerous trials were made to discover, if possible, some reducing agent which, though proper to change nitrates to nitrites in neutral solutions, should not form peroxide of hydrogen in such solutions; but all these efforts were unsuccessful. In point of fact there are comparatively few chemicals capable of reducing nitrates to nitrites in presence of much water; while most, if not all, of these substances readily form peroxide of hydrogen when left in contact with water and air. Among metals,* I have found only iron and lead that seem to be at all fit to be used as substitutes for cadmium or zinc, in testing for nitrates by the old method. Both these metals readily reduce nitrates to nitrites in dilute neutral solutions at the boiling temperature; but they, as well as magnesium, aluminum, and copper,† cause the formation of peroxide of hydrogen also, when boiled in pure water. Aluminum, though it reduces nitrates to nitrites in neutral solutions, seems to be inferior to zinc for this purpose, and magnesium, though it reduces nitrates very readily in neutral solutions, seems to form peroxide of hydrogen even more easily than cadmium.

The behavior of iron and lead towards nitrates will appear from the following statement: Neutral solutions of nitrate of potash, containing in 100 c. c. of water 0·01 grm. (or more) of N_2O_5, gave a strong reaction with the iodo-starch, after having been boiled five minutes upon iron wire; with 0·001 grm. N_2O_5 the reaction soon appeared, and with 0·0001 grm. N_2O_5 the reaction appeared after some little time. A special experiment was made, as follows, to test the efficiency of iron as compared with that of cadmium or zinc‡: 50 c. c. of pure water were boiled for five minutes upon iron wire in one flask, while in another flask 50 c. c. of pure water, plus 0·0005 grm. N_2O_5, in the form of nitrate of potash, were boiled upon an equal amount

* I have, as yet, made no experiments with the alkali metals or their amalgams.

† And various other metals, as recorded in Gmelin Kraut's Handbuch, i (2 Abth.), p. 56.

‡ Since the above statement, that iron forms peroxide of hydrogen on being boiled with water in contact with air, may seem to conflict with Schœnbein's observation that the peroxide is not formed when iron is shaken in water and air, it may be well to give the evidence on which it depends. Pure water was boiled with iron wire for five minutes; the cold liquid was mixed with iodo-zinc-starch solution and dilute sulphuric acid, and left to stand over night. A purplish coloration was obtained. On repeating the experiment, a precisely similar reaction was observed. This coloration is rather less, it should be said, than that obtained from the other metals enumerated above; but is, nevertheless, perfectly distinct and characteristic. In still another experiment, where pure water was boiled upon sheet iron, no reaction for peroxide of hydrogen was obtained. The liquid assumed a rusty tint, and no blue coloration could be perceived.

of the iron wire. When cold, the liquids were transferred to porcelain capsules, mixed with iodo-zinc-starch and acid, and left to stand over night. Decided reactions were obtained in both instances, but the liquid to which the nitrate had been added was deeper colored than the other, and the difference in tint between the contents of the two dishes seemed to be rather more marked than was the case in similar experiments where cadmium or zinc had been used instead of iron. It is not unlikely that iron would have been rather better fitted than either of these metals, for use in testing for nitrates according to the old plan.

On repeating this last experiment with metallic lead, instead of iron, decided reactions were obtained with the iodo-starch in both dishes; but the colorations were of about the same depth as those ordinarily obtained with cadmium, and that obtained from the nitrate solution was no stronger than that from the pure water.

Solutions of nitrate of potash (0·01 grm. N_2O_5 to 100 c. c. water), made alkaline with potash or with lime, were reduced, with formation of some nitrite, when boiled for five minutes upon iron, or left to stand over night in contact with the metal in the cold; but the reactions with iodo-starch that were obtained in this way were less strong than those got by operating upon neutral solutions of the nitrate.

The following substances failed to reduce nitrate of potash when boiled for five minutes with neutral solutions of that substance, containing 0·025 grm. N_2O_5 in 100 c. c. water, or, at the least, no reaction could be obtained with the iodo-starch after using them, viz: filter-paper, phosphorus (ordinary and amorphous), arsenic, ferrous sulphate, ferrous sulphide, and sulphite of lead. No reaction was obtained when acidulated solutions of the nitrate, of the above mentioned strength, were boiled with stannous chloride, ferrous sulphate, glucose, or arsenic. No reduction to nitrite was detected when solutions of the nitrate that had been mixed with lime were digested with ordinary or amorphous phosphorus, glucose, or ferrous sulphide, or when a solution that had been mixed with hydrate of potash was boiled upon metallic arsenic.

On the other hand, recently precipitated cupreous oxide, boiled for five minutes with neutral, acid, and alkaline solutions of nitrate of potash (0·01 N_2O_5 in 100 c. c. water), reduced some of the nitrate in each instance, so that reactions were obtained on adding iodo-starch to the several filtrates, but as the reactions were not very strong there seemed to be little encouragement to proceed with the inquiry.

If it were less difficult than it is, to manipulate with thoroughly boiled water so that no atmospheric air should come

into contact with it, it would be possible, by using such water, to avoid the interference of peroxide of hydrogen, in testing for nitrates in neutral solutions by Schœnbein's process; for, out of contact with the air, no peroxide of hydrogen is formed by the action of cadmium or zinc upon water that has been thoroughly boiled, in a glass flask, provided with a long and very narrow outlet. Even when no special pains are taken to preserve such water from contact with the atmosphere after the boiling, it is easy to perceive that peroxide of hydrogen does not readily form in it. So too, though in a lesser degree, with water that has been well nigh completely deprived of air by distillation in the vacuum of an air-pump. But no such inability to yield peroxide of hydrogen was observed in water that had been boiled for a long time in a copper flask, into the neck of which a long and very narrow brass tube had been soldered. The boiled water from the copper flask gave a reaction for the peroxide even when tested directly, without having been put in contact with any other metal.

I am much indebted to my assistant, Mr. D. S. Lewis, for his coöperation in this investigation.

Bussey Institution, Jamaica Plain, Mass., June, 1876.

ART. XXIII.—*Note on the double decomposition of Potassic Bromide and Sodic Chloride;* by J. H. BILL, Surgeon U. S. Army.

IN the practice of analytical chemistry it is the custom in arranging and recording the results to associate the "strongest acid" with the "strongest base." Thus, if barium, potassium, sulphuric and nitric anhydrides are found in a compound, in the statement of the analysis we associate together the barium and sulphuric anhydride and the potassium and nitric anhydride.

In this record nothing is assumed, for the basic sulphate separates as an insoluble powder, the potassic nitrate remaining in solution a soluble crystalloid.

Again, if potassium, sodium, chlorine and bromine, are found in a mixture we record the results as so much potassic chloride and sodic bromide, or if we mix solutions of potassic bromide and sodic chloride we hold that potassic chloride and sodic bromide exist in the mixture in consequence of a double decomposition. On what do we rest such an assumption? Is it on anything more than analogy? The haloid salts of potassium and of sodium have nearly the same solubility, and crystalline forms. We get no precipitate on mixing their solutions, nor characteristic crystals on evaporating these, nor change of

color in the solutions themselves, nor other evidence that the chemical relations of the several bodies have been altered. In short our belief in this alteration is purely hypothetical.

Several years ago while conducting a physiological research on the action of the bromides I observed certain facts which I here offer as a demonstration of the proposition that potassic bromide and sodic chloride, when brought together in solution, undergo double decomposition.

If five or six grams of potassic bromide are administered to a healthy man, his urine of the succeeding twenty-four hours will show the following changes: Nearly all the potassium ingested as potassic bromide will be found in the urine in addition to that naturally present, united with chlorine augmented according to the amount of bromide taken; the sodium scarcely altered in quantity; the sulphates and phosphates unchanged; only a very little bromine will be found. Bromides, however, may be detected for two weeks after the last dose taken, whilst excess of potassium will be found only after the first day.

I can account for these facts only on the supposition that the potassic bromide ingested was decomposed by the sodic chloride of the blood, potassic chloride—excreted by the urine—and sodic bromide—retained in the blood as a substitute for sodic chloride—resulting.

Further, this decomposition was the result of simple chemical affinity. We know of no instance where a "vital force" changes in the body the usual action of chemical force and we have no right to assume it here. We hold the reaction therefore to be a universal one. I submit the average result of three analyses when no bromide was taken, and the average results of six analyses of urine when the body was under the influence of from five to ten grams of potassic bromide. The results show the amounts of the whole twenty-four hours, all the urine for that period being collected. The method was to incinerate a portion of the urine and from the ash to separate the alkaline earths, sulphates and phosphates. The sodium and potassium were then estimated in the form of chlorides by the indirect method. The chlorine and bromine were also estimated indirectly.

	Potassium. grms.	Sodium. grms.	Chlorine. grms.	Bromide. grms.
No bromide taken	4·21	7·67	9·56	----
Seven grains (average) of bromide taken	6·52	7·82	11·45	0·04

I have waited for a chance to extend these experiments to the reaction of the iodides and chlorides, but seeing no probability that an immediate opportunity of doing so will present itself I publish this note for what it is worth.

New York, June 15, 1876.

ART. XXIV.—*Note on Erosion;* by JAMES D. DANA.

IN Professor Gilbert's very valuable paper on "The Colorado Plateau Province,"* the author speaks of the process of erosion† as including the three general divisions, "(1) *weathering*, (2) *transportation*, and (3) *corrasion*;" and states that "corrasion is performed by solution, and by mechanical wear;" that the mechanical wear is due to the blows which the moving fragments [of the detritus] deal upon the stream bed, and among themselves; and that "the element of velocity is of double importance, since it determines, not only the speed, but, to a great extent, the size of the pestles which grind the rocks." He further observes, in his excellent explanatory analysis of the mechanical action of flowing water, that the energy of a stream is used up in transportation, corrasion, and friction, either one or all; and that sometimes partly also, but not usually so, in producing an increase in the velocity of flow; that the energy "in a clear stream is entirely consumed in friction on its bottom," and in one that is loaded to its full capacity with detritus, in transportation. From these principles, he concludes that "if a stream has no load of detritus it corrades only by solution," that is, by softening and dissolving away the rocks.

The eroding action directly connected with friction is not dwelt upon by Professor Gilbert, nor distinctly included in the "general divisions" of erosion which he enumerates, although he is unquestionably familiar with the facts; and a few words on the subject are therefore here added, since an appreciation of the work which may thus be done appears to be essential to a full understanding of the method of cañon-making.

The impinging of the flowing waters against the bottom and sides of a stream generally causes, besides a diminution of velocity owing to friction, an overcoming of adhesion, and of other sources of resistance to displacement, in the material acted upon. The operation is exhibited, on a small scale, at the placers of California and the Rocky Mountains, where a stream of water—strictly a water-fall—strikes, in a jet, the rather firmly consolidated gravel bank, and, in an incredibly short time, levels the thick deposits over a large area. The water that impinges has "no load of detritus," and yet it erodes with tremendous efficiency. The flooded rivers that tear houses from their foundations, and break off or uproot trees, afford other examples; for the work is, first, rending, and then, transportation. The sudden rise of several feet or yards in a mountain stream, or along a western cañon, sometimes occurring as

* This volume, pages 16, 85. † Ibid., p. 89.

a consequence of a severe and short storm, often affords, as is well known, vast effects of this kind.

Flowing water, causes easily, through this method of erosion, a rapid destruction of those deposits that are imperfectly cemented; but not these alone. It may cause a rapid degradation also of hard rocks. For granite, quartzyte, sandstone, limestone, and other rocks equally firm, are generally jointed throughout, that is, intersected everywhere by a system of fractures; and many kinds also break easily into slates, flags, or chips, even without a previous weakening by weathering. Consequently, when the waters, swollen to flood height and quickened immensely in velocity, plunge along a gorge, they readily tear, shove, or wrench out of place blocks or slabs exposed in the walls to their violence. As the waters hurry on, they dash in many places, with the full force of the stream, against projecting ledges, and drive into all crevices or openings, causing a vast amount of degradation; and much additional by undermining and toppling down the piles of strata above.

Such waters in the rocky regions of the west, where the bed and gorge are rock-made, transport, in their greatest floods but a small part of the detritus which at so rapid a rate of flow they could carry, and hence, comparatively little of the energy is used up in transportation. Moreover, the descent in the cañoned streams of the Rocky Mountain slopes is often—much oftener, probably, than Professor Gilbert seems to allow—sufficient to produce an increasing velocity as a direct consequence of the fall, and hence an accumulation, thereby, of working force or energy; and all this would augment greatly the results. The clearer the waters, the greater will be the velocity, and, hence, the vaster the amount of degradation by this means—though detritus would increase the effects if the velocity remained the same.

It has been well said that glaciers depend largely for their work in the way of erosion on the jointed condition of the rocks over which they pass, these making it easy for the moving ice to force out of place great masses for transportation, and so make rapid progress in degradation; and that the abrasion by means of stones in the bottom of the ice is comparatively of trifling importance. I am strongly inclined to believe that the same general fact is true as regards erosion by rapid rivers over a rocky region; and hence that the results of *friction*, or of the *blows of the impinging torrent* are the chief means of degradation in most cases of cañon-making; that *abrasion*, or the wear of the sides and bottom by transported stones and earth (included under corrasion by Professor Gilbert), is of next importance; while the mutual wear of the transported particles or fragments, or *corrasion*, aids in clearing the gorge of the dislodged material.

ART. XXV.—*Classified List of Rocks observed in the Huronian Series, south of Lake Superior, with remarks on their abundance, transitions, and geographical distribution; also a tabular presentation of the Sequence of the beds, with an Hypothesis of Equivalency;* by T. B. BROOKS.

DURING the last ten years I have explored more or less thoroughly the east and north portions—about one-third—of the large Archæan area lying southwest of Lake Superior, embracing the iron and copper regions of northern Michigan and Wisconsin.* Besides observations in the field, I have collected and catalogued over 3,000 rock specimens, mostly Huronian, embracing, it is believed, all the kinds and most of the varieties to be observed in that portion of the region which came under my observation. The most interesting of these specimens having now been more or less thoroughly studied by competent lithologists, I feel warranted in preparing the following list of names with classification. They are based largely on a microscopic study of over 200 thin sections of typical rocks, made by Dr. A. Wichmann† of Leipsic under the supervision of Prof. Zirkel, an equal amount of similar work by Mr. Chas. E. Wright,‡ together with a considerable number of similar examinations made by Mr. Frank Rutley of London. Dr. T. S. Hunt has compared a large number with the Huronian rocks of Canada; Dr. A. Törnebohm of Stockholm has made similar comparisons with rocks of Scandinavia, and Herr B. Wapler of Freiberg, with the rocks of Saxony. Prof. Geo. J. Brush has made several analyses and determinations of essential mineral constituents. Prof. R. Pumpelly placed at my disposal his numerous field-notes, made in the Archæan area. Mr. A. A. Julien has minutely described the physical characters of these rocks in Appendix A, vol. ii, of the Michigan Geological Reports, 1873.

From this material the nomenclature given below has been chiefly drawn. As many of the rocks are fine-grained, often aphanitic mixtures of obscure amphibolic and feldspathic minerals, the different kinds and varieties graduating into each other, it is to be expected that similar specimens would often receive different names. This has been particularly the case with the hornblendic rocks, diorytes, diabases, and certain related chloritic schists, also to a less extent with hydro-magne-

* For geographical distribution and structural relations of the copper-bearing rocks, see Brooks and Pumpelly, Am. Jour. Sci., vol. iii, June, 1872; also for Archæan of Michigan, their Map No. 1, Atlas of Michigan Geological Survey, 1873. But little of Northern Wisconsin is mapped in detail.

† Dr. Wichmann is preparing a paper embodying the results of his labors.

‡ Mr. Wright's work was done for the Wisconsin Geological Survey, but the results are not yet published.

sian, argillaceous, and micaceous rocks. An effort has been made to reconcile these different views through the results of the microscopic investigations of the gentlemen above named, as well as by observations in the field, where a fine-grained or altered rock can often be traced through its various transitions to a coarser and typical variety.

The age and distribution of the different members of the Huronian series given in the annexed table are chiefly based on my own observations; use, however, has been made of the notes of Prof. Pumpelly and Mr. Wright, and the publications of Dr. Credner, whose descriptions of the transitions of the various rocks are excellent. The hypothetical scheme of equivalency presented in the table is my own.* That subject was also discussed in a paper entitled, "On the youngest Huronian Rocks south of Lake Superior, and the age of the Copper-bearing Series."†

The thickness of the Huronian series, which are everywhere sharply folded, thus presenting their upturned edges which are often abruptly curved, striking at every point of the compass,—can only be determined with exactness by a protracted study of many sections. Exclusive of the youngest observed member (the granite bed XX, only recently made out), the thickness seems least in the Marquette and western districts, where it is believed not to exceed 6,000 feet, and greatest in the Menominee Region, where it may exceed 12,000 feet. I do not know how Dr. Credner obtained his estimate of 18,000 ft.‡ as the thickness of the sixteen oldest beds of my scheme (the only ones he examined) in the Menominee Region. In one instance, however, owing to his having mistaken cleavage for bedding planes (bed IX), he overlooked at least one synclinal and one anticlinal fold, thus counting the same bed at least three times.

The lithological classification adopted is that given in the second edition of Dana's Manual of Geology, 1875, as best embracing the facts. No other classification of rocks that has come under my notice admits the so-called greenstones among metamorphic rocks, where, following the lead of the Canadian geologists, I would place the diorytes, diabases, and related schists, so abundant in the Huronian area south of Lake Superior, especially in the eastern portion, which is nearest the Huronian of Canada.

* Dr. H. Credner makes my oldest fourteen beds of the Marquette series the equivalents of the quartzyte bed II of the Menominee series. See Zeitschrift der deutschen geologischen Gesellschaft, xxi Band, 1869. His having failed to recognize the upper Huronian, detracts considerably from the weight of this hypothesis.

† Published in the proceding volume of this Journal, page 206.

‡ See his article referred to in the above note.

Explanations.

1st. The numbers following many names refer to typical specimens of that rock contained in my Michigan State Collection (see catalogue * in Geological Survey of Michigan, 1873, vol. ii, p. 201), partial duplicate suites of which were furnished the University of Michigan, Boston Institute of Technology, Harvard University, Sheffield Scientific School, the Schools of Mines in New York and Philadelphia, Smithsonian Institution, as well as several other American and foreign institutions. See list in the report named above. The same numbers repeated in the table indicate their stratigraphical position, and the region from which obtained.†

2d. Those rocks marked L have also been observed in the Laurentian system, which has however been but little explored. No Huronian rocks are believed to be identical with those of the copper-bearing series. although some of the greenstones have considerable resemblance.

3d. The Marquette region embraces the important iron-mining district southeast of Keeweenaw Bay; of which Marquette in Michigan is the chief port. About fifty or sixty miles south is the undeveloped Menominee iron region extending into Wisconsin. One hundred and twenty-five miles west of Marquette, on Black River, Mich., and thirty miles farther west, where Bad River crosses the Penokie Iron Range, Wis., the Huronian series is well exposed. See table.

4th. The Roman numerals of the table express the approximate relative age of the twenty beds into which it has been found convenient to divide the Huronian of the Marquette and Menominee regions, numbered from the oldest upward. The equivalency has been extended with less certainty to the Black River and Bad River series, and with still less to the Huronian of Canada. See table.

5th. The names of rocks which have not been observed in the Huronian are usually printed in italics.

6th. The varieties of each kind of rock are arranged in the order of relative abundance, so far as known.

1. Fragmental Rocks, exclusive of Limestones.

True quartz-conglomerates are not abundant, but occur in the Middle Huronian, both in the Marquette and Menominee Regions; and in the latter, at the base of the series, is a protogine conglomerate holding pebbles of granite, gneiss, and quartz.

*** A supplementary revised and extended descriptive catalogue of this typical suite, now much extended, is in course of preparation.**

† The specimen numbers in italics were selected by Dr. Wichmann as possessing the greatest lithological interest. Duplicates have been given to R. Fuess, Berlin, from which I understand he will furnish mounted thin sections.

RIVER SERIES, ogebic and Montreal River, ICHIGAN.	BAD RIVER AND PENOKIE GAP, WISCONSIN.
llly and Brooks.	T. B. Brooks.
IR SILURIAN. LE WITH COPPER SERIES,	LOWER SILURIAN. NON-CONFORMABLE WITH COPPER SERIES, Believed to be non-conformable with the following.
re believed to nformably and conceal pper Huronian.	Red, gray, coarse and fine grained, *granitic* rock, rarely schistose.
	Greenstone or hornblende rock, apparently chloritic, (somewhat soft, but tough).
stone with green cherty? red specks of jasper and e.	[Covered about ½ mile.]
lds grains of glassy quartz ritic.	Clay slate?
magnetic quartzose flag. flag ores.)	
nd brown, *banded, ferrug-ate,* with strong rhombo-	*Magnetic amphibolic quartzose flags,* and quartzose magnetic ore. 148. Heavy bed forming crest of ridge.
enish *banded schist,* weath- parently *chloritic,* with *jas-* ntains pyrites. In places ic and again aphanitic.	Black *clay slate* without oblique cleavage.

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Laminæ of quartz-sandstone occur in magnetite at one locality, and arenaceous quartzytes approaching sandstones at several points. Shaly argillaceous rocks without oblique cleavage, in places highly carbonaceous, are somewhat common; and earthy limonites, having the character of residual deposits, occur in the Marquette Region. These rocks would strictly belong in this class, but as their quantity is comparatively small, and as they are interstratified with and graduate into metamorphic rocks, of which they often appear to be altered forms, they are classed below, where they may stand for the least metamorphosed varieties of the series.

2. Metamorphic Rocks, not Calcareous.

1. *The Mica-bearing Series.*

(1.) *Granite.* (L.) Confined to the youngest bed; also occurs rarely in veins in Lower and Upper Huronian. Common (gray)—*101*. Gneissic. Semi-porphyritic.

(2.) *Pegmatyte.*

(3.) *Granulyte?*—146. Very rare, may exist in the Menominee Region.

(4.) *Gneiss.* (L.) Not abundant, mostly associated with granite. Common (gray)—*102*. Granitic—7. Semi-porphyritic. Compact, related to greenstones—*103*.

(5.) *Mica Schist.* (L.) Abundant, especially in the younger rocks of the Marquette Region. Common, blackish and brownish. Often staurolitic and holding andalusite (Brush)—61. Garnetiferous—108, 56? Quartzose. Hornblendic—*106* (massive, semi-porphyritic?—rare). Green, chloritic—107 (associated with greenstone). Gray, arenaceous, semi-schistose, with mica-scales—*104*. Gneissic—90. Magnetic (L.)—*109*, (rare). Actinolitic—105. The last three varieties have been observed only in the Menominee Region.

(6.) *Mica Slate.* (L).—53?

(7.) *Hydro-mica Slate?*—53, 54. Unctuous-feeling, micaceous rocks, interstratified with iron-ores; they have been called talcoid schists. Sericite—*112*.

8. *Clay Slate or Argillyte.* *a.* Without oblique cleavage, usually in independent beds. Chloritic—114? Carbonaceous (including so-called graphitic varieties)—64, 115. Ferruginous, associated with hematites and limonites. Micaceous, (phyllyte)—111, 56? Feldspathic (arenaceous obscure varieties)—*55?* Pyritiferous. *b.* With oblique cleavage, usually associated with quartzytes or marbles—113, 20. Roofing—81. Novaculyte—10, *12*, 13.

2. *Hornblendic Series.*

(1.) *Syenyte* (containing quartz). (L.)

(1*b*.) *Syenytic Gneiss* (Hornblende Gneiss). (L.)—*117*. Not abundant; rare in the Marquette Region, where it only occurs as a transition variety of greenstone.

(2.) *Hyposyenyte* (quartzless syenyte). Observed only in the Lower Huronian near Marquette, associated with greenstone, into which it seems to graduate. Rich in orthoclase—*116*. Hornblendic—77.

(2*b*.) *Zircon-syenyte.*

(3.) *Dioryte*—75, *118*. Grayish-green, fine to coarse grained. Abundant, especially in the eastern part of the Marquette Region, graduating into hornblendic rocks on the one hand, and, through schistose varieties and diabases (?), into chloritic schists on the other. Hornblendic. Chloritic (schistose)—71? Semi-porphyritic.

(3′.) *Gabbro** ?—69. Confined to bed XV, in the Menominee Region.

(4.) *Hypersthenyte.*

(5.) *Diabasyte.*† Abundant, especially south of L'Anse. This name is often applied by Dr. Wichmann to obscure, fine-grained greenstones which have usually been called diorytes, dioritic schists and chloritic diorytes. Decomposed—99, *120*, 121, 122. Often closely related to one variety of chloritic schist—70. Green, related to dioryte—72, 119, 69. Black, somewhat coarse-grained, highly crystalline, distinct from the other greenstones —*82*. Porphyritic?—83. Micaceous?—31.

(6.) *Hornblende Schist.* (L.) Abundant. Greenish-black, coarse-grained, semi-schistose to massive, graduating into greenstone —18, 22, 30, 88. Eminently schistose, fine-grained, associated with mica schist—128, *125*. Micaceous—29, *127*, 71? Chloritic —76. Calcareous—*124*, rare.

(7.) *Hornblendyte.* (L.?)—*126*. Far less abundant than the schist.

(8.) *Actinolyte*—*129*. Chiefly confined to the Menominee Region. Not abundant.

Anthophyllite Schist‡ (Brush). Quite abundant in the Marquette and Menominee Regions, and always associated with magnetite. Manganiferous—*58*, 59. Quartzose—130. Garnetiferous (eklogyte)—*27*.§

* Dana does not mention gabbro among the metamorphic rocks. As several lithologists agree on the name, and the bed has all of the structural characteristics of the others of this series, I place it here, although Dr. Wichmann regards the rock as diabase.

† From microscopic researches, Dr. Wichmann and Mr. Törnebohme, with whom Prof. Zirkel agrees, regard these Huronian greenstones, the diorytes and diabases, as mostly diabasytes, and consider them of eruptive origin. Regarding them myself as metamorphic, I should have employed the term *meta-diabase*, as lately suggested by Prof. Dana, had it come to my knowledge in time.—Note in letter dated Edinburgh, June 27.

‡ This rock does not occur as a distinct kind in Dana's classification.

§ Dr. Wichmann's microscopic examinations lead him to regard this rock as made up largely of actinolite.—Letter, dated July 27.

(9.) *Pyroxenyte* (augite rock). (10.) *Lherzolyte.* (11.) *Ossipyte.* (12.) *Unakyte.*

3. ***Felsitic, Epidotic, and Garnet Rocks*** (L. ?),

Having the mass, or base, compact (crypto-crystalline).

No typical rocks of this family have been observed. The nearest kind is a gray, magnetic, amphibolic schist, containing garnets, and closely related to the anthophyllite schists, but which Dr. Wichmann designates eklogyte—*27.*

4. ***Chrysolite (or Olivine) Rocks.*** Not observed.

5. ***Hydrous Magnesian Series.***

(1.) *Protogine* (L.)—8. Not abundant. Quartzyte graduates into this rock in the Marquette Region. In the lowest Huronian of the Menominee Region, holding pebbles of granite, gneiss and quartz—65.

(2.) *Feldspathic Protogine Gneiss?*—147. Has been called graywacke. Occurs only in the Menominee Region in one bed.

(3.) *Talcose Slate*—74. A typical kind has been observed only at Marquette. Unctuous-feeling micaceous and chloritic rocks, often called talcose, are more abundant.

(4.) *Steatyte or Soapstone.*—Said to exist.

(5.) *Chloritic Slate* (schist). (L. ?) Abundant. A hard, very unevenly schistose, gray-green variety, associated with greenstones and hornblendic schists, of which it appears to be an altered or chloritic form, (has received different names)—133, 70? Gray-green, splitting into somewhat uneven thick slates, and related to micaceous and argillaceous rocks—132, *134.* A fissile variety, graduating into clay slate, under which it should perhaps be classed—*55*, 114? Dark-green, pure, massive, containing pseudomorphs after magnetite, garnet, and amphibole, occurs in iron-ore—*89.* Ferruginous. Micaceous, in greenstone. Compact, magnetic, conchoidal fracture—28?

(6.) *Chloritic Argillyte.* A slate termed chloro-argillaceous, is very abundant in the Menominee Region—114. Often carbonaceous.

(7.) *Serpentine*—*78.* Very rare. Apparently altered greenstone, and having somewhat of an eruptive character.

(8.) *Ophiolyte.* (9.) *Schilleryte.*

6. ***Hydrous Aluminous Rocks.*** Not observed.

7. ***Quartzose Rocks.***

(1.) *Quartzyte.* Very abundant, graduating into marble on one hand, and into protogine on the other, containing beds of clay slate with oblique cleavage. White to light-gray, massive, arenaceous, often with glassy grains, occasionally with ripple-marks, and on Black River showing the false stratification

of sandstone—8, 21, *137*. Micaceous quartz schist, often conglomeritic—*140*, 50, 51. Quartz conglomerate (see remarks under "Fragmental Rocks"), associated with and constituting a variety of the above—145. Chloritic arenaceous—138. Blue-gray, arenaceous, weathering to a brown sandstone—*139*. Banded magnetite and arenaceous quartz schist—52. Micaceous and specular iron—32, 33, 49. Limonitic—26. (The three last varieties are also classed under Iron-ore rocks.) Calcareous.

(2.) *Siliceous Schists*, compact, often slaty, generally ferruginous, and graduating into siliceous flaggy iron-ores, are abundant. Poor in iron. Rich in iron (siliceous flag ores)—23, 36, 68. (See Iron-ore rocks.)

(3.) *Chert.* A flinty rock, flaggy to slaty, between siliceous schist and jasper, abundant only in the middle of the Black River series. Sometimes brecciated—85, 84? Lydianstone—very rare.

(4.) *Itacolumyte.*

(5.) *Jasper Rock.* An impure reddish variety, banded with specular ore, is abundant in the Marquette Region—*37*. Better characterized, banded, often ferruginous, jaspers occur with chert in the Black River series. Sometimes brecciated—84, 85?

(6.) *Buhrstone.*

8. *Iron-ore Rocks.*

Magnetites, *Hematites* (usually specular), *Limonites*, and related ferruginous rocks are very abundant in the Middle and Lower Huronian, especially in the eastern portion of this Huronian area, while they are comparatively rare in the same series in Canada. At least seven out of the twenty beds of the Marquette Region are ferruginous, and four have produced first-class ores. The rich specular hematite, which is so far most extensively mined, is mostly confined, however, to bed XIII, in which the richest magnetites also occur. There is less iron in the Menominee Region, and still less and of lower grade, so far as observed, in the Black River and Bad River series.

The magnetites and specular hematites graduate into each other through martite, which is abundant. They are also sometimes interstratified in the same bed, although seldom in juxtaposition. Nearly the same may be said of the hematites and limonites, but not of the latter and magnetites, which are never found together. These facts support the hypothesis that these ores, whatever their origin, were once all magnetites, part of which were afterward oxidized to hematites, and part of these in turn into limonites.

No rocks are embraced below which do not occur in considerable beds. To include all of them I have found it necessary to considerably expand the skeleton given by Professor Dana,

and to add limonites, which are so closely related to the others that it was not attempted to separate them here.

Iron-oxide, except as disseminated grains of magnetite and in a few instances in small unworkable beds, is entirely absent from the Laurentian and Copper-bearing series of the Archæan south of Lake Superior, while in Canada the largest deposits are reported as occurring in the Laurentian. Titaniferous iron-ore, so abundant in the Archæan of Canada and northern New York, has not been observed south of Lake Superior. In several hundred analyses of these ores,* I have only once seen "a trace" of titanium reported. Franklinite has not been observed.

(A.) *Magnetites and Magnetic Quartzose and Amphibolic Rocks.* Most abundant and, except the amphibolic kinds, found only in typical forms in the western part of the Marquette Region.

a. *Rich in iron (iron-ores).*

*a*1. Blackish granular magnetites, massive to semi-schistose, fine to coarse grained, compact to friable—39, 40, 41, 42.

*a*2. Cryptocrystalline, compact, tabular, schistose, sometimes containing actinolite—17?

b. *Poor in iron, rich in quartz, (magnetic rocks). Most abundant in the Marquette Region, especially in the western part; also abundant in the Penokie (Bad River) series.*

*b*1. Banded, arenaceous quartz and magnetite layers—52.

*b*2. Intimate mixtures of magnetite (with hematite) and quartzose matter, often cherty. Magnetic siliceous schist (flag ore)—23, 15. Both varieties graduate into ferruginous quartzytes.

c. *Ferruginous rocks, rich in amphibole,—the iron-oxide mostly magnetic. (Here are embraced such anthophyllite schists as are rich in iron.) Tolerably abundant in the Menominee Region.*

*c*1. Banded quartzose, amphibolic (mostly anthophyllitic, according to Brush), magnetic schists—130, 17. According to Dr. Wichmann the iron-ore at Penokie Gap is a related variety—148.

*c*2. Manganiferous anthophyllitic magnetite schists—*58*. Only in western part of the Marquette Region, constituting bed XVII.

*c*3. Garnetiferous anthophyllitic magnetite schist (eklogyte)—*27*. Only in one bed in the Marquette Region.

(B.) *Specular Hematites, Martites, and siliceous, jaspery, argillaceous Hematitic rocks.* Most abundant and typical in the eastern part of the Menominee Region.

a. *Rich in iron.*

*a*1. Granular, massive to semi-schistose, specular hematite and martite. Usually contain a little magnetite. Not so abundant as the magnetites of corresponding structure—5.

* See my Michigan Report, vol. i, chap. x, 1873.

*a*2. Chloritic, semi-schistose, specular ores, not abundant, —43.

*a*3. Specular-iron schists, often slaty, and passing into micaceous-iron varieties (the most abundant form of hematite)—38, 45, 47, 48.

*a*4. Micaceous-iron slaty schist; graduates into the last, *a*3. When interstratified with magnetic ore, it usually contains magnetite—46, 49.

*a*5. Kaolinic specular schist—2, 44. Rare and observed only in the eastern part of the Marquette Region.

*a*6. Purplish to pigeon color, shaly to sandy, generally rich in iron, dull specular ore—136, 67. Confined to the eastern part of the Menominee Region.

b. *Quartzose specular Hematites, poor in iron, poor in quartz. Abundant. Graduates into hematitic quartz schist.*

*b*1. Banded, micaceous-iron, quartzose schist—16, 32, 33. Abundant in the Marquette Region.

*b*2. Banded specular-iron with jaspery quartz ("mixed ore"), the laminæ often plicated and faulted to the extent sometimes of producing a breccia. Abundant with specular ores in the eastern part of the Marquette Region—*37*. Similar but more jaspery and less ferruginous rocks occur in the Black River series—84.

*b*3. Intimate mixture of specular hematite (often magnetic) with quartzose matter, often cherty. Hematitic siliceous schist (flag ore). Very abundant—68, 19, 36. Sometimes contains grains, apparently of decomposed garnets (bird's-eye ore)—6.

c. Hematitic argillaceous, hydro-magnesian and micaceous schists, sometimes graduating into limonitic varieties, and usually associated with rich iron-ore. Poor in iron; generally diffused, but not abundant. Included under varieties of clay and chloritic slate and mica schist.

(C.) *Limonitic Quartzose Ores and Rocks, often containing hematite and manganese.* Usually some shade of dull brown, generally soft and more or less earthy. Often contain ochre and kaolin (Brush), and probably turgite. Appear to be of the nature of residual deposits, from the partial dissolving out of the silica and the hydration of the iron of quartzose hematites.

a. Rich in iron ("soft hematite ores"). Most abundant in the Marquette Region, although absent from the magnetic district about Lake Michigamme. Also found in the Menominee Region.

*a*1. With little or no manganese—34, 35. A hard, red variety, rich in iron, and containing four per cent of water occurs in the Menominee Region—135.

*a*2. Richer in manganese (specimens of pure pyrolusite being sometimes found)—24, 25.

b. Poor in iron, rich in quartz, often ochrey. Graduates into limonitic quartz schist. A very siliceous variety of the two prevailing kinds in which a less proportion of the silica seems to have been dissolved out—26, 57. Generally diffused but not abundant. Was not observed in the Penokie series.

3. Calcareous Rocks.—Carbonates and Sulphates.

1. *Uncrystalline Limestones.* Not observed.
2. *Crystalline Limestone.*

Tolerably abundant, especially in the Menominee Region. Usually dolomitic. In the Marquette Region it is always associated with quartzyte, and contains interstratified beds of clay slate (novaculyte) with oblique cleavage.

(1.) *Granular Limestone*—rare. Ferruginous—97; very rare, probably a vein. Brown, micaceous—144; observed at one point in the Marquette Region.

(2.) *Dolomyte and Dolomitic Limestone.**—Most if not all the limestones in beds contain more or less carbonate of magnesia.

The prevailing variety is light-grayish, sometimes mottled, fine-grained, semi-schistose, often containing quartzose laminæ, which project on weathered surface (ribbed)—9, 66, *143*. A crystalline, medium to coarse grained massive variety, free from quartz:—white in the Menominee Region, where it is most abundant; sometimes salmon-colored in the Marquette Region—11. White crystalline dolomyte, holding numerous crystals of tremolite, and, according to Dr. Wichmann, of wollastonite (142), occurs in the northeast part of the Menominee Region.

Siliceous; besides the variety banded with quartz laminæ, is one in which the quartz exists in grains, appearing on the weathering surface almost like sand,—*141*. It occurs midway between the Marquette and Menominee Regions. Argillaceous, in thin beds, at Lake Antoine, Menominee Region.

(3.) *Consisting of Sulphate of Lime.* Not observed.

4. Igneous or Eruptive Rocks.

(Including those metamorphic rocks which in a plastic state have been forced into adjacent cracks, thus taking the form of eruptive rocks).

1. *Feldspathic Series.*

(1.) Granite dykes or veins have been observed only in the Lower and Upper Huronian of the Menominee Region. Red ferruginous granite in iron-ore at two points—96. Gray granite

* Dr. Credner erroneously assigns certain dolomytes and conglomerates to the Laurentian. See Zeitschrift der deutschen geologischen Gesellschaft, xxi Band 1869, p. 516. Marbles, so abundant in the Laurentian of Eastern Canada have not as yet I believe been observed in that system as developed south of the lake.

in the hornblende and mica schists of bed XIX, at the contact with the overlying granite bed.

Granite dykes are very numerous in the Laurentian.

2. *Hornblende and Pyroxene Series.*

Some geologists would include here a considerable portion of the bedded greenstones embraced under metamorphic rocks.

"Trap"-dikes in a bed of magnetite occur at the Washington mine. At a few other points very small ones have been seen. Black, fine-grained, massive, hard, tough. Has been called doleritic, dioritic, and, by Dr. Wichmann, diabase. (Has but little resemblance to the bedded rocks so-named)—*79*, 94. The greenstone dikes, sometimes of great thickness, so numerous in the Laurentian, are not so fine-grained and are more dioritic in character.

3. *Hydrous Magnesian Schistose Rocks.*

These are found in dyke-like masses crossing quartzytes, iron-ores, and greenstones, sometimes apparently formed from the abraded material of the walls of a fault,*—73. Sometimes the rock is erratic, as in the case of the soft chloritic? schist dyke in massive quartzyte at the northeast corner of Teal Lake. Not observed in the Laurentian.

Dresden, Saxony, Dec. 21, 1875.

ART. XXVI.—*Seventh Catalogue of New Double Stars;* by S. W. BURNHAM.

THE double stars in the following list have been discovered during the past year with the Clark & Sons 6-inch refractor previously used in these observations. The six catalogues preceding this will be found respectively in Monthly Notices of the Royal Astronomical Society for March, May and December, 1874, June and November, 1875, and Astronomische Nachrichten, No. 2062. The reference number in the first column is continued through the series.

Four pairs from the old double star catalogues have been found to be again more closely double. These are:

σ 39
H 4935
H III. 113 (=Σ 2630 *rej*)
H 1489

Through the kindness of the distinguished observer, Baron Dembowski, I am enabled to attach his careful micrometrical measurements of a few of these objects.

* Faults of any great magnitude are rare in the Huronian.

No.	Designation.	R. A. 1880.	Decl. 1880.	Pos.	Dist.	Mags.
		h m s	° ′	°	″	
391	B.A.C. 10	0 3 14	−28 39	110·±	0·7 ±	6·0...6·0
392	B.A.C. 46	0 10 31	+60 52	...	20· ±	6.0..11·8
393	L 291	0 12 12	−21 48	30·±	0·5 ±	7·0...9·0
394	L 678	0 24 14	+46 52	300·±	1· ±	8·0...8·0
395	Ceti 82	0 31 9	−25 26	135·±	0·5 ±	6·0...6·0
396	B.A.C. 282	0 56 13	+60 26	85·±	1· ±	6.0..11·0
397	L 1943	1 0 53	+46 12	160·±	10· ±	8·0..10·5
398	O². Arg 1200	1 4 52	+47 10	60·±	2· ±	8·0...8·0
399	Ceti 211	1 21 46	−11 31	301·2	1·49	6·5..10·0
400	W¹III. 50	3 5 18	− 4 16	45·±	15· ±	7·0..11·5
401	W¹III. 830	3 44 10	− 1 52	260·±	4· ±	7·0..11·0
402	W¹IV. 318	4 17 3	− 1 33	75·±	5· ±	8·5..10·5
403	W¹IV. 379	4 19 18	− 2 20	100·3	2·00	7·0...8·5
404	Arg(8°) 805	4 49 51	+ 8 58	113·4	1·49	9·0...9·5
405	W¹V. 1045	5 42 22	−13 34	150·±	10· ±	8·5..11·0
406	W¹V. 1068	5 43 1	−13 28	260·±	8· ±	9·0..12·0
407	W¹VIII. 1159	8 45 50	− 6 20	160·±	6· ±	8·0..10·0
408	R 2231	8 48 58	+63 54	350·±	2· ±	7·0..10·0
409	W¹VIII. 1383	8 54 55	− 8 43	180·±	10· ±	8·0..10·0
410	B.A.C. 3127	9 4 30	−25 19	160·±	1·5 ±	7·0...9·0
411	Lac 4360	10 30 25	−26 3	310·±	1·3 ±	7·0...9·0
412	L 22722	12 2 10	−17 55	160·±	1·5 ±	8·0...9·5
413	Lac 5686	13 42 15	−27 46	110·2	77·7	6·8..10·0
414	Centauri 315	14 34 42	−30 25	160·±	1· ±	6·5...6·5
415	O². Arg 15675 A and B	15 44 50	+65 57	336·8	12·72	8·5..11·5
	A and C			357·6	30·82	12·0
416	Scorpii 155 A and B	17 10 46	−34 51	240·±	1·8 ±	6·0...8·5
	A and C			130·±	15· ±	10·0

391. This is κ' Sculptoris of some of the star catalogues.

393. Very difficult.

395. B.A.C. 160, magnitude 6.

396. A pair of the most extraordinary difficulty, very close and unequal. Not an easy test for a large aperture. Heis gives this as naked-eye star.

397. There is but little doubt this is the pair observed for H 2015, but error of 1° in Herschel's declination. There is nothing in his place.

399. The small star was suspected in Dec., 1873, but not verified until two years later. Measured by Dembowski (1876·07). There is a very distant companion in the direction of 67° which makes the pair σ 39.

402. Found in looking for Σ 547, the companion of which was invisible; so noted by Dembowski in 1865.

403. Measures by Dembowski (1876·07).

404. Found in verifying a suspected error of 1^m R. A. in OΣ 90. Measures by Dembowski (1876·07.)

405. This and the next following were found in looking for Σ801 *rej.*

408. In Argelander $6{\cdot}7^m$.

411. A naked-eye star according to Heis.

413. Not properly a double star, but inserted for its remarkable red color. Dembowski calls it "perfect blood red." Most of the red stars of this class are smaller, and not so strongly marked. The small star appeared decidedly blue. My approximate measures of angle and distance. Not in Schjellerup's Catalogue of Red Stars.

415. Measures by Dembowski (1876·39).

416. A and C make the double star, H 4935. Close pair easy, although very low.

No.	Designation.	R. A. 1880.	Decl. 1880.	Pos.	Dist.	Mags.
		h m s	° ′	°	″	
417	L 32929	17 52 13	+39 27	270·±	1·5 ±	8·0...9·5
418	O². Arg 17847	18 1 28	+64 26	240·±	10· ±	8·5..11·5
419	L 34259	18 25 42	− 7 55	40·±	1·5 ±	8·0...9·5
420	W²XVIII. 722 A and B	18 25 53	+37 5	280·±	1·5 ±	8·5..10·0
	A and C			200·±	20· ±	11·0
421	W²XVIII. 1452 A and B	18 48 3	+43 15	270·±	1· ±	8·5...9·0
	A and C			230·±	30· ±	9·0
422	O¹. Arg 19281	19 7 34	−18 16	50·±	8· ±	8·5..11·5
423	O¹. Arg 19560	19 20 17	−29 44	110·±	1·2 ±	8·0...8·5
424	W²XIX. 676	19 23 5	+35 49	60·±	2·5 ±	8·5..10·0
425	L 38087	19 52 15	+19 58	241·1	1·33	8·5...8·7
426	O². Arg 19938	19 59 13	+54 18	140·±	6· ±	8·0..10·0
427	O². Arg 19952	19 59 28	+54 20	160·±	3· +	8.0..10·0
428	Arg(12°) 4226	20 1 7	+12 36	346·4	0·52	7·2...8·0
429	L 38521 A and B	20 1 27	+35 27	30·±	7· ±	7·5..11·5
	A and C			301·0	10·79	10·0
	A and D			90·±	25· ±	11·0
	A and E			28·2	36·52	9·0
430	Arg (35°) 4008 A and B	20 6 48	+35 28	30·±	1· ±	9·0...9·0
	A, B and C =H 1489			55·1	20· ±	9·5
431	W²XX. 530	20 15 25	+35 53	240·±	0·5	8·0...8·5
432	W²XX. 698	20 20 13	+35 23	220·±	1·2	8·0..10·0
433	Arg (50°) 2399 A and B	20 23 36	+55 55	220·±	6· ±	9·0..11·0
	A and C			250·±	20· ±	10·5
434	W²XX. 941	20 28 4	+41 27	100·±	1·2 ±	8·5...9·0
435	L 39867	20 33 14	+14 35	112·5	2·95	8·0..11·0
436	O².Arg. 23612	22 6 44	+57 21	340·±	15·±	8·0..10·8

417. In the field with Σ2246.

419. Found in looking for one of Herschel's suspected pairs, H 5496.

425. Measured by Dembowski (1875·72). He has detected a very minute companion about 10″ following, which I failed to see.

426. In the same field with No. 427, the two forming with a third 8ᵐ star a small triangle.

428. Close and difficult. The wide pair of small stars in the field is H 1476. The large star is rather strangely wanting in all the other Star Catalogues I have access to. Measures by Dembowski, two observations (1875·73).

429. The companions B and D are new. A, C and E make H III. 113= Σ 2630 *rej.* = Sh 314. Given with Herschel's measures (1783·7). In a splendid field.

430. As a wide pair this is H 1489, entered by Herschel. 236°·3 : 13″± : 9–10..10. There is probably an error of 180° in his angle, as the preceding star is obviously the largest, and so in Argelander who noted the magnitudes as 9·3 and 9·5. By a rough measure I found 55°·1, showing no material change has occurred since 1828. From the faintness of the components, the close pair is a very difficult object under ordinary conditions.

431. Very difficult.

433. Found in trying to identify H N. 89.

435. About 26′ *sf* β Delphini. Measures by Dembowski (1875·76).

Chicago, July 27, 1876.

ART. XXVII.—*An account of a New Meteoric Stone that fell on the 25th of March,* 1865, *in Wisconsin, identical with the Meno-Meteorite;* by J. LAWRENCE SMITH, Louisville, Ky.

THE Wisconsin meteorite, which fell on the 25th of March, 1865, and is one of much interest, attracted no attention at the time of its fall outside of the immediate neighborhood where it was observed, a fact due to the comparatively sparsely inhabited condition of the country. It was brought to my attention only a few months ago by one living in the region not far from where it fell. He sent me a small fragment that had been presented to him, and so similar was it in its appearance to the Meno-Meteorite that fell in 1861, that, not having heard of any fall at the period when this one was said to have been found, I considered it at first a fragment of that rare meteorite which had found its way to that part of the country. But on further inquiry and search I was soon satisfied that it was a piece of an undescribed meteorite; I have designated it the *Claywater* meteorite.

The following is the account I have been able to gather in relation to its fall.

In Vernon County, State of Wisconsin, about lat. 43° 30′, long. 91° 10′, at nine on the morning of the 25th of March, 1865, a body was seen by several persons passing rapidly through the atmosphere, accompanied with a loud rumbling noise. It was luminous and showed flashes of light. Its course was from northwest to southeast, and it exploded at a supposed altitude of four miles. At the time that the small fragments were thrown off from the main body, a noise like the rolling of musketry was heard. The main body seemed to have a rotary motion, making about one revolution in two seconds of time.

The observer from whom the above facts were obtained, thinks that the main body did not fall but passed into space.

No fragments were found until about five days after the fall, when two were discovered, weighing in all fifteen hundred grams. The curves of the surfaces of these fragments would indicate that they had pertained to a mass having a diameter of about thirty centimeters. No data were obtained by which to calculate its velocity, but the observer already referred to says that it was variously estimated from fifteen to twenty-five miles per second. Of the two fragments that fell, one has been lost or destroyed; the other has been placed in my possession by Mr. Claywater, who made the observations already recorded, and to whom we are indebted for the preservation of what we have of this interesting meteorite; for it differs in its physical aspects from any yet observed in this country.

The fragment in my possession, and which is all that has been recovered from this fall, weighed seven hundred grams; about one-third of the surface was covered with a thick, dull black crust; the fractured surfaces are quite granular, and its structure porous; it belongs to the hard variety of meteoric stones. Examined with a glass the grains are of a dirty green color with a greasy aspect, and in some places have a globular structure. Particles of iron are disseminated abundantly through the mass, and particles of troilite are also visible.

Its specific gravity is 3·66 and it is composed of:

Stony matter	78·33	per cent.
Metallic particles	17·07	"
Troilite	4·60	"
	100·00	

The stony matter treated with aqua regia furnished:

Soluble matter	47·20	per cent.
Insoluble matter	52·80	"
	100·00	

The composition of these two portions are:

	Soluble.	Insoluble.
Silica	32·55	57·41
Protoxide of iron	30·40	9·50
Alumina	trace.	4·00
Magnesia	35·80	22·80
Lime		3·70
Soda	·60	2·01
	99·35	99·42

The metallic particles, completely separated from the stony portion, are composed of:

Iron	92·15
Nickel	7·37
Cobalt	·28
Copper } very minute quantity;	
Phosphorus } not estimated.	99·80

In regarding the above analyses, it is very evident that the meteorite is made up of:

Bronzite, with probably a little anorthite	41·35
Hyalosiderite (olivine)	36·98
Nickeliferous iron	17·07
Troilite	4·60

As I was not able to find any analysis of the Meno (Alt. Strelitz Mecklenburg) meteorite, which fell Oct. 1st, 1861, at midday, and as the physical aspects of the one just described

were so strikingly similar to those of the Meno, I was interested to ascertain the mineralogical and chemical relations of the two.

An examination was made of this last meteorite, the result of which is placed in contrast with those obtained from the Claywater meteorite.

	Claywater.	Meno.
Stony matter	78·33	77·76
Metallic particles	17·07	18·00
Troilite	4·60	4·24
	100·00	100·00
Stony part, soluble	47·20	48·70
Stony part, insoluble	52·80	51·30
	100·00	100·00
Stony part, analyzed as a whole.		
Silica	44·98	44·70
Protoxide of iron and alumina	21·95	22·26
Magnesia	29·30	28·97
Lime	1·80	1·85
Soda	1·32	1·20
	99·35	98·98
Metallic particles.		
Iron	92·15	91·86
Nickel	7·37	7·53
Cobalt	·28	·13
Copper and phosphorus	traces in both.	
Specific gravity	3·66	3·65

It will be observed that the specific gravity of the Meno here given, is lower than that stated in Poggendorf's Annalen, cxvii, 637, it being there given as 4·1; but this must have been taken with a fragment containing some large particles of iron. My determination was made on two good average fragments, broken from a very fine specimen sent me by the late Wm. Nevill, of London, which were examined in my usual method, viz: after weighing the fragment to immerse it in water contained in a small vessel, and, placing this beneath the receiver of an air pump, thereby extracting all the air from the surface and cavities, and completing the process in the usual way.

In regarding the above comparative statement of the composition of these meteorites, it will be seen that the compositions of the two as made out by me do not differ more than those of two fragments of the same meteorite, while they both differ in their *physical aspects* from the ordinary type of meteorites, and, in fact, they have few or no parallels in the collections of these bodies; there are certainly none in mine, embracing stony meteorites representing over one hundred falls.

ART. XXVIII.—*Five new Variables, and a new Planet, found at the Litchfield Observatory of Hamilton College;* by C. H. F. PETERS.

RECENTLY the variability has been ascertained by me of stars in the following positions:

Right Asc. h.	m.	s.	Decl.		Max. mag.	Min.
10	16	32	+14°	42′·7	10	∞
15	13	21	−19	53 ·0	6	10
16	0	19	−21	8 ·9	10	∞
20	6	15	−22	24 ·0	11	∞
21	0	32	−21	54 ·6	10	∞

The limits of magnitude given are gathered from only occasional notes taken during the later years. For fixing them more accurately, and also for determining the times of periodicity, more systematic and continuous watching would be required.

The positions refer to the equinox of 1860, which is the epoch of my manuscript charts.

A new planet, 11th magnitude, was found here last night (Aug. 9), of which I give to-day only the approximately reduced position:

Aug. 9, 1876. $10^h\ 34^m\ 27^s$.

$\alpha(165) = 21^h\ 27^m\ 42^s$. $\delta(165) = -10°\ 0'\ 18''$.

The motion is nearly parallel to equator, perhaps slightly southward, 56^s in right ascension.

ART. XXIX.—*On the Relation of Franklinite to the Spinel Group of Minerals;* by GEORGE H. SEYMS. (Contributions from the Sheffield Laboratory, No. XLI.)

THE amount of iron in Franklinite, as shown by numerous determinations that have been made in the Sheffield laboratory, is subject to considerable variation. To determine whether this variation affects the general character of the mineral, and to supplement the recent investigations upon its composition and relation to the Spinel group, was the object in making the following analyses.

The first experiments were made on perfectly formed crystals, in a matrix of limestone, from Mine Hill. The analyses gave results which may be best expressed as follows:

	I.	II.	Mean.
SiO_2	·17	·17	·17
Fe_2O_3	63·42	63·38	63·40
Mn_2O_3	4·44	4·44	4·44
MnO	10·39	10·53	10·46
ZnO	23·11	23·12	23·11
	101·53	101·64	101·58

The relation of the metals to the oxygen, taking the mean of the two analyses, is given in the subjoined statement.

	Metals.	Oxygen.	
Fe_2	44·38	19·02	20·37
Mn_2	3·09	1·35	
Mn	8·10	2·36	6·92
Zn	18·55	4·56	

Dividing the amount of each element by its atomic weight gives as the ratio of the metals to the oxygen, R : O :: 3 : 3·999 $=R_3O_4$ nearly, or an oxygen ratio of the protoxides to the sesquioxides of 1 : ·981 or nearly 1 : 1, which corresponds to the formula of the Spinel group, ($R_2O_3+RO=R_3O_4$).

The state of oxidation of the manganese here given was determined by solution of the mineral in HCl, and estimation of the clorine liberated, according to Bunsen's iodine method. Two experiments gave chlorine equivalent to ·47 per cent and ·43 per cent of oxygen, mean ·45, which requires the presence of 4·44 per cent Mn_2O_3.

The analyses following were made on a sample taken from an aggregation of imperfect crystals from Sterling Hill. While the crystals in the former case were but very feebly magnetic, these were strongly so, though they showed no signs of magnetite as an admixture.

	I.	II.	III.	IV.	Mean.
SiO_2	·08	——	——	·08	·08
Al_2O_3	·65	·65	——	..	·65
Fe_2O_3	67·43	67·50	67·32	67·42	67·42
FeO	15·68	15·62	——	——	15·65
ZnO	6·79	6·81	6·76	6·75	6·78
MnO	9·71	9·47	9·51	9·44	9·53
	100·31	100·16	99·97	99·99	100·12

This gives from the mean of the four analyses:

	Metals.	Oxygen.	
Al_2	·35	·30	20·53
Fe_2	47·19	20·23	
Fe	12·17	3·48	6·97
Zn	5·44	1·34	
Mn	7·38	2·15	

Deducing from this the atomic ratio of the metals to the oxygen we have as a result R : O :: 1 : 1·331 or as 3 : 3·994 = R_3O_4, and we find the oxygen ratio of the protoxides to the sesquioxides to be as 1 : ·981 or nearly 1 : 1.

The amount of iron protoxide shown in these results was found directly in the usual way by potassium permanganate.

As it has been stated that some varieties of franklinite give with HCl a solution containing $FeCl_2$, and at the same time evolve chlorine, this variety was quantitatively tested by Bunsen's method with a negative result. Careful experiment failed also to show any iron protoxide in the variety first analyzed. In both cases, therefore, the total amount of oxygen may be said to be fairly determined.

The results of these analyses give in both cases a ratio very nearly corresponding to that of spinel, notwithstanding the great differences in the relative amounts of the iron, zinc and manganese.

April 6th, 1876.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Thermic formation of Ozone.*—Berthelot has studied thermo-chemically the formation of ozone. Pure and dry oxygen was passed through a tube, where it was subjected to the influence of the silent electric discharge, and then into a calorimetric flask containing 500 c.c. of a solution of arsenous acid in hydrochloric acid, previously titered. At the end of twenty to thirty minutes, six to nine liters of oxygen had passed through the calorimeter, and its temperature had been raised one-third of a degree. By passing the oxygen current alone through the apparatus under the same conditions for an equal time, both before and after the experiment, the thermal data were rendered complete. The arsenic solution was treated with a graduated solution of permanganate in excess, and then titered back with a standard solution of oxalic acid. In this way the amount of arsenous acid oxidized and therefore the amount of ozone absorbed, was determined. In two experiments, the oxygen absorbed was 30·3 and 51·9 milligrams, corresponding to 90·9 and 155·7 milligrams of ozone; the heat set free being 118·2 and 223·7 calories respectively. Whence for one molecule, 48 grams, the heat is equal to +68·8 calories. Subtracting from this the heat produced in the oxidation of a molecule of arsenous acid, determined by Favre and by Thomsen to be +39·2 calories, we have +29·6 calories for the heat set free by conversion of one molecule of ozone into oxygen, and of course −29·6 calories in the reverse

process. This value is one-half greater than that given in the formation of the same volume of nitrogen monoxide or of chlorine monoxide, in both of which the value is -18. It is two-thirds of that given in the formation of nitrogen dioxide $-43{\cdot}3$. In the three cases of direct synthesis of compound gases under the influence of electricity, the author finds:—

$O_4+O_2=(O_3)_2$ (4 volumes) $-29{\cdot}6$ cal. (spark or silent discharge).
$N_2+O_4=N_2O_4$ (4 volumes) $-24{\cdot}3$ cal. (spark).
$C_4+H_4=(C_2H_2)_2$ (4 volumes) $-64{\cdot}$ cal. (electric arc),—

an obvious proof of the function of electricity in chemical synthesis. Ozone therefore is a body in whose formation heat is absorbed, and the activity of which is due to this heat, which is again set free when it combines. It is thus a magazine of energy stored up under the influence of electricity. This is notable when it is remembered that it is condensed oxygen; condensation generally setting free heat.—*C. R.*, lxxxii, 1281, June, 1876.

G. F. B.

2. *On Hydrogen antimonide or Stibine.*—Owing to the difficulty of freeing stibine from hydrogen, and to the fact that it spontaneously decomposes even at ordinary temperatures, its exact composition has never been ascertained. JONES has examined the question anew and has obtained results which are closely approximate. The method he preferred for preparing the gas was to allow a strong solution of antimony in hydrochloric acid to drop on a considerable bulk of zinc either granulated or in powder. Chancing to observe the ready action of the gas on sulphur, according to the reaction

$$(SbH_3)_2+S_6=Sb_2S_3+(H_2S)_3$$

the author made use of the fact in order to analyze it. The dry gas was passed through weighed U-tubes containing sulphur, then through a calcium chloride tube, and then through a strong solution of copper acetate. The apparatus being placed in sunlight (the reaction not taking place in the dark) it was found that a secondary reaction took place between the stibine and the hydrogen sulphide $(SbH_3)_2+(H_2S)_3=Sb_2S_3+(H_2)_6$. By screening the empty portions of the tubes the quantity of sulphide thus formed was lessened; and by allowing for it, the amount of hydrogen combined with 122 parts (one atom) of antimony was found to be in two experiments, 3·34 and 3·13 respectively; whence the author concludes upon SbH_3 as the correct formula of stibine. He found the reaction of this gas on sulphur so delicate a test for the presence of light that he made some photometric and photographic experiments with it. It is an excellent test for antimony.—*J. Chem. Soc.*, clxi, 641, May, 1876. G. F. B.

3. *Compounds of Columbium and Tantalum with Nitrogen and with Carbon.*—JOLY has made a series of experiments on the compounds formed by reducing at high temperatures oxides of columbium and tantalum in carbon crucibles. A mixture of

columbic oxide, sodium carbonate and pure carbon thus heated to whiteness, affords a crystalline mass of an olive color and friable. Heated to the temperature of fusion of nickel for six or seven hours, long violet-gray brilliant needles are obtained, which analysis showed to be a mixture of columbium carbide and nitride. The product formed at the temperature of fusion of steel contained $\frac{2}{3}$ of a molecule of the latter to one of the former; when heated for a longer time $\frac{4}{5}$ of a molecule; and that formed at the temperature of fusion of manganese, $\frac{1}{5}$ to 1. Tantalic acid thus treated acts similarly except that the carburation may be carried higher; one product, of a beautiful bronze-yellow color, obtained at the temperature of melted steel, containing only 0·7 per cent of nitrogen. —*Bull. Soc. Ch.*, II, xxv, 506, June, 1876. G. F. B.

4. *New mode of effecting the Substitution of Chlorine or Bromine in Organic Compounds.*—DAMOISEAU has called attention to the remarkable way in which carbon facilitates the introduction of chlorine and bromine into organic compounds. The form of carbon he prefers is obtained by calcining a mixture of dried blood and potassium carbonate, and subsequent washing and igniting. If the animal charcoal thus prepared be placed in a tube heated to 250° to 400°, and a mixture of chlorine with, for example, ethyl chloride gas be passed through it, abundant white fumes of hydrochloric acid appear, and oily drops collect on the walls of the tube. By varying the proportion of the two gases, monochlorinated, dichlorinated, trichlorinated, tetrachlorinated or finally perchlorinated ethyl chloride may be obtained singly and almost pure. Other chlorides act similarly. With bromine the effect is even greater. It is remarkable that if the tube be filled with pumice, wood charcoal, alone or platinized, or even with platinum sponge itself, the effect is insignificant.—*C R.*, lxxxiii, 60, July, 1876. G. F. B.

5. *On Physical Isomerism.*—In studying nitrometachlornitrobenzene, LAUBENHEIMER has discovered an excellent example of physical isomerism. To prepare this substance, metachlornitrobenzene was treated with a mixture of fuming nitric and sulphuric acids with the aid of heat. On pouring the whole into water, a yellow oil fell down, which almost entirely solidified to a crystalline mass on cooling. On investigation it appeared that this nitrometachlornitrobenzene existed in four distinct modifications, physically isomeric, three of which were solid, the other liquid. The first or α-modification is obtained by dissolving the crude product in warm alcohol and allowing it to cool. An oil separates at first, in which after some time crystals appear which by repeating the operation become large thick prisms. Any of the other forms when melted, crystallize in this form on introducing a fragment of it, as the liquid cools. The crystals are monoclinic twins with a well-defined cleavage, in which $a:b:c=1·8873:1:0·9810$ and $\gamma=114° 14'$. The plane of the optic axes is perpendicular to the plane of symmetry. Angle between them 45° 31′ for Na light. Double refraction strong and negative. Fusing point

36·3°. The second, or β-modification is obtained by fusing the first completely at a temperature of 39° to 40°, and allowing to cool. Long concentric groups of thin prisms are in this way obtained. Crystals of α, after five weeks, yield β on crystallization from alcohol. Either of the varieties fused and allowed to cool yield β on introducing a crystal of this form. It also is monoclinic but without cleavage. The axis-ratio $a:b:c = 0·6249:1:0·5600$ and $\gamma = 91°\ 27'$. Its fusing point is 37·1°. The third or γ-modification crystallized from the aqueous solution into which the mixture was poured in preparing the substance. It is also the most permanent form of them all, both α and β crystals becoming turbid in twenty-four hours and being completely converted into γ in a few weeks. The crystals are orthorhombic, show a distinct cleavage, and have a moderate, positive double refraction. The angle between the optic axes is for sodium light 47° 17′. The fusing point is 38·8°. The fluid modification was obtained by heating any of the other forms to 42°. On cooling the substance remained permanently fluid, though a fragment of either solid form caused crystallization at once. The author explains this isomerism on the hypothesis of Naumann, that physical molecules are aggregations of chemical molecules, and that the stable molecules are composed of a larger number of chemical molecules than the unstable. Hence the fusing points of the latter are lower, the specific gravity is less and the specific heat is greater.—*Ber. Berl. Chem. Ges.*, ix, 760, June, 1876. G. F. B.

6. *Synthesis of Allantoin.*—As pyruvic acid acting upon urea gives a homologue of allantoin, GRIMAUX acted upon urea with glyoxylic acid in expectation of obtaining allantoin itself. One part of glyoxylic acid was heated to 100° with two parts of urea for eight to ten hours. The mass was extracted with boiling alcohol, and the residue was dissolved in twelve to fifteen times its weight of hot water. On cooling beautiful crystals were deposited, which gave on analysis the formula $C_4H_6N_4O_3$, a glyoxylic diureide. Its identity with allantoin was completely proved by its chemical reactions, by its solubility, by its crystalline form, etc. The rational formula

$$\begin{array}{l}\mathrm{CH}\diagup\mathrm{NH-CO-NH_2}\\ |\quad\ \diagdown\mathrm{NH}\diagdown\\ |\qquad\qquad\quad \mathrm{CO}\\ \mathrm{CO-NH}\diagup\end{array}$$

is assigned to it by the author.—*C. R.*, lxxxiii, 62, July, 1876. G. F. B.

7. *High Pressure Manometer.*—M. L. CAILLETET, in a recent examination of the change of volume which a cylindrical reservoir of glass undergoes, found this change exactly proportional to the pressure. Experiment carried to the point of fracture showed that this law held at even the highest pressure, and that moreover the glass underwent no permanent change in shape. An extremely simple manometer is based on this principle. It consists of a sort of glass thermometer whose cylindrical reservoir is enclosed in spherical cups and filled with colored liquid or mercury. The capillary tube is calibrated with care and is

enlarged at one point so that it may be attached to the reservoir by gutta percha passing through a copper orifice. The latter is then closed by a screw surrounding the tube. Liquid being pressed into the outer reservoir compresses the glass and causes the mercury to rise in the tube by an amount proportional to the pressure.

It is indispensible that the temperature of the apparatus should be constant, which is easily accomplished by surrounding it with water or melting ice. In rapid determinations even these precautions are needless. It is only necessary to take care before applying the pressure to see that the level of the liquid coincides with the zero of the graduated scale. If this is not the case the scale should be raised or lowered to the proper position. By varying the relative dimensions of the tube and reservoir any desired sensibility may be attained. A comparison of this instrument with the open-air manometer of the College of France shows that the liquid displaced by the diminution of the glass envelope rises to a height exactly proportional to the pressure exercised upon its walls. In fact this should be so, for if we take for abscissas the pressures and for ordinates the volumes of the peizometer, the compressibility of the glass being very small this volume changes but little, so that for very different pressures p and p', the volumes v and v' differ but little; consequently the curve, whatever it may be, will approach very nearly to a straight line. Consequently the change in volume of the reservoir ought to be proportional to the increase in pressure, and this within very wide limits, provided the change in volume is small.—*Journ. de Phys.*, v, 181. E. C. P.

8. *Waves on Lake Geneva.*—Dr. Forel gave the London Physical Society an account of some interesting observations which he has recently made on the periodic waves which take place on the Swiss Lakes and are there called "Seiches." It has long been observed that the waters of most of these lakes are subject to a more or less regular rise and fall, which at times has been found to be as much as one or two meters. Dr. Forel has studied this phenomenon in nine different lakes, and finds that it varies with the length and depth of the lake and is in every way analogous to that already studied by Prof. Guthrie in artificial troughs, and follows the laws which he has deduced from his experiments. Most of the observations in Switzerland were made on the Lake of Geneva, but that of Neuchâtel was found to be best fitted for the study of the subject, possessing as it does an extremely regular geometric form. The apparatus he employed was very sensitive to the motion of the water, being capable of registering the waves caused by a steamboat half an hour after it had passed and five minutes before its arrival, and was so constructed as to eliminate the effect of common waves, and to register the motion side by side with a record of the state of the barometer, on paper kept in continuous motion. While he found the duration of waves to be ten minutes at Monges it was seventy

minutes at Geneva, and this is explained by the narrowness of the neck of the lake at the latter place. This period he proved to be independent of the amplitude, and to be least in the shortest lakes. For shallow lakes the period is lengthened, and his observations show that the period is a function of the length and depth and that longitudinal and transverse waves may coexist, just as Prof. Guthrie has shown to be the case in troughs.—*Nature*, xiv, 164. E. C. P.

9. *Friction of the Ether.*—Mr. W. M. HICKS drew the attention of the Cambridge Philosophical Society to some experiments of Messrs. Stewart and Tait on the heating of disks by rapid rotation in vacuo, and which they referred to the friction of the ether. He showed that it was not necessary to have recourse to this explanation, that nearly all the effects could be accounted for if it is supposed that the disc, through the rapid rotation, has expanded and consequently been lowered in temperature, that whilst rotating it is raised to the temperature of the surrounding region, and, therefore, when the rotation is stopped, and the disc has shrunk to its former size, it will give out the heat it had taken in whilst rotating. In the case of silver it was shown that the disc ought to show a rise of ·4°C., if the rotation had been continued for some time, and this was compared with the rise of ·47°C. which Messrs. Stewart and Tait had observed in an aluminum disc, thus showing that the effect was of the same order of magnitude in the two cases. It was also shown that if the whole heating were due to ethereal friction, that this friction would be ·0006 lbs. per square foot, and that if we suppose this amount to act on the surface of the earth, the day would be lengthened in the course of a century by something like ·006″.—*Nature*, xiv, 144. E. C. P.

10. *Specific heat of Gases.*—M. M. KUNDT and WARBURG have determined experimentally the ratio of the two specific heats of mercury vapor which has been supposed by chemists to consist of monatomic molecules. According to the Kinetic theory of gases, supposing the gaseous molecule to consist of only one atom, the relation of the two specific heats (as Clausius has shown) would be 1·666. The lower number obtained by experiment for several gases may probably be explained by the complete constitution of their molecules. The method here employed was to produce a sound in two glass tubes placed end to end, and containing, one mercury vapor, the other air. Having introduced powder into the tubes they observed the distances between the nodes of vibration. Applying the formula for the velocity of sound which includes the densities, temperatures, and the ratio of the specific heats, and taking as the value of this ratio in the case of air, the number 1·405, they obtain, for mercury vapor the number 1·67, which may be considered as fully in accord with the number 1·666 furnished by theory.—*Pogg. Ann.*, iii, 1876. *Nature*, xiv, 182. E. C. P.

II. Geology and Mineralogy.

1. *Geological Survey of Canada;* Alfred R. C. Selwyn, F.R.S., Director. *Report of Progress* for 1874–75. Montreal. 320 pp. 8vo. 1876.—This report consists of an introductory report by Mr. Selwyn; reports on the country west of Lake Manitoba and Winnepegosis, and on the geology of Lake Winnipeg, by Mr. R. Bell; on the country between the Upper Assineboine River and Lakes Winnepegosis and Manitoba, by Mr. J. W. Spencer; on explorations in British Columbia, by Mr. J. Richardson; on observations in New Brunswick, by Prof. Bailey and Mr. Matthew; on boring operations in New Brunswick, and on the iron ore deposits of Carlton Co., N. B., by Mr. R. W. Ells; on portions of Frontenac and Lanark Counties, and on the economic minerals, by Mr. H. G. Vennor; on explorations in Cape Breton, by Mr. C. Robb; on statistics of the trade and manufacture of Canadian salt, by Mr. J. L. Smith; on some Canadian minerals, by Mr. B. J. Harrington; chemical contributions, by C. H. Hoffmann. The reports contain much of value to science. We cite a few of the facts:

Glacial Striæ.—According to Mr Bell the glacial striæ on the east side of Lake Winnepeg, and between Lake Winnipeg and Lake Superior, run generally to the southwestward. This direction confirms the view, presented by the writer, that the great glacier had its maximum height above the sea-level between that region and the Atlantic coast along the area of greatest precipitation, and that it thinned down toward the continental interior.

Heights of Lake Winnipeg and others.—Mr. Bell states that the Canadian Pacific Railway Survey obtained, by a series of spirit levels carried all the way from the sea, for the height above sea-level of Lake Winnipeg, 710 feet; St. Martin's Lake, 737 feet; Lake Manitoba, 752 feet; Lakes Winnipegosis and Cedar, 770 feet; Lake of the Woods, 1,042 feet.

Mascarene Series of New Brunswick, Upper Silurian in age.—Messrs. Baily and Matthew in their report state that the so-called "Mascarene series" of Southern New Brunswick, containing diorytes, felsytes, argillytes, is of Upper Silurian age. It includes below, sandstones, and red, green, and purplish argillytes, affording on the southwest side of Passamaquoddy Bay numerous shells of the genera *Modiolopsis*, *Lingula*, and *Loxonema*; and above, diorytes, felsytes (the color usually brick red) and red slates. On the Mascarene shore the rocks have a thickness of about 2000 feet. The lowest division, consisting of about 400 feet of feldspathic slates, affords Upper Silurian fossils at Back Bay of La Tete Harbor, at Frye's Island and at Oak Bay. The next division, about 600 feet thick, is stated to afford remains of "*Cordaites*, a large *Cyclopteris*, probably a *Sphenopteris*, and a *Carpolite*, and striate and punctate stems of Ferns."

Analyses and Descriptions of Minerals.—Mr. Harrington gives

analyses of an aluminous pyroxene from Grenville; sodalite and natrolite, from felsytic dikes, intersecting Trenton limestones near Montreal; Chromiferous serpentine from Bolton or Melbourne; pyrrhotite of Elizabethtown; serpentine containing magnesite; feldspar of a dioryte, near anorthite; and Mr. Hoffmann, analyses of kaolinite; a Hisingerite-like mineral from Elizabethtown; a feldspar (labradorite) of a dioryte from North Sherbrooke; and a pyrite from Londonderry, Nova Scotia, besides analyses also of some mineral waters. J. D. D.

2. *Bulletin of the Geological and Geographical Survey of the Territories*, Dr. F. V. HAYDEN in charge. Vol. ii, No. 4, pp. 279–374 (closing the volume). Washington, August 4, 1876. Department of the Interior.—This new number of the Bulletin contains the following papers: Notes on the Geology of Northeastern New Mexico, by O. ST. JOHN; on Sexual, Individual and Geographical variation in *Leucosticte Tephrocotis*, and on geographical variation among North American Mammals, especially in respect to size, by J. A. ALLEN; on fossils from Vancouver's and Sucia Islands, and other northwestern localities, and on the New Genus, *Uintacrinus* of Grinnell, by F. B. MEEK. Mr. St. John treats of the Cretaceous and Tertiary strata of the region, the mesas of basalt, besides the general features of the valleys, parks and ridges, and illustrates his subject by admirable sketchy views, illustrating both the geology and scenery. He states that "the basin of the Canadian is partially surrounded on two sides by the immense basaltic-capped mesas, the flat summits of which rise 1,000 to 1,500 feet above its surface." The plain itself is everywhere traversed by dikes, the rocks of which are the same as those of the mesas. The Capulin country to the east of the Canadian has similar mesas of varying height; and all were once probably united. The basaltic layers usually overlie directly Cretaceous or Tertiary beds, and were ejected at the close of the Tertiary.

Mr. Allen shows that the individuals of the species of *Felidæ* of North America increase in size to the southward; of the *Canidæ* and *Procyonidæ* increase to the northward and decrease to the southward; of the *Ursidæ*, increase to the northward; of the *Sciuridæ*, and *Leporidæ* also increase to the northward or decrease to the southward; and he states the general conclusion—that the individuals are largest in the region "where the group reaches its highest development, or where it has what may be termed its center of distribution;" and "the most typical or most generalized representatives of a group are found near its center of distribution, outlying forms being generally more or less "aberrant" or "specialized." See for a further notice of Mr. Allen's memoir, by Prof. Verrill, page 238 of this volume.

Mr. Meek describes three Carboniferous species from the borders of Washington Territory near 49° north and 114° west, and several Cretaceous species from Vancouver's and the Sucia Islands. The paper is illustrated by six plates. Mr. Meek also describes

and figures specimens of the *Uintacrinus socialis* of Grinnell—a Cretaceous Crinoid,—and points out some characters that were not distinct in Grinnell's specimens.

3. *Report of the Exploring Expedition from Sante Fé, New Mexico, to the junction of the Grand and Green Rivers of the Great Colorado of the West*, in 1859, under the Commander, Capt. (now Colonel) J. N. MACOMB, Corps Topogr. Engineers; with the *Geological Report* of Prof. J. S. NEWBERRY, Geologist of the Expedition. Engineers' Department, U. S. Army. 148 pp. 4to.—This volume, excepting the first four pages occupied with the General Report of Colonel Macomb, is made up of the Geological Report of Prof. Newberry, a Paleontological report on the Carboniferous and Triassic fossils, by the same author, and another on the Cretaceous Fossils, by Mr. F. B. Meek. The text is illustrated by a number of excellent lithographs printed in colors, representing geological views, and the paleontological descriptions by eight plates of fossils.

The expedition was in the field during the summer of 1859; and the report of Dr. Newberry, its geologist, bears the date "May 1, 1860;" but the "breaking out of the rebellion" arrested its publication, and only recently was its printing ordered.

Dr. Newberry remarks that the region has since been the field of several exploring and surveying expeditions, and the subjects of their reports; so that the results he obtained have been partly anticipated. He has wisely, however, published his report as it was written, without reference to the later works. The report is therefore all the more valuable as independent testimony with regard to the geological structure of the country. It treats of the coal and the Coal-measures of Kansas, and the extension of the Carboniferous (Coal-measure) limestone westward; of the succeeding Permian, first met at Dragoon Creek; of the Gypsum formation (Triassic or Triassic and Jurassic) which overlies the Permian from the west side of Cottonwood Creek to Walnut Creek; of the Lower Cretaceous beds of Walnut Creek to Pawnee Fork; of the "Tertiary basin of the Arkansas," as Dr. Newberry had before designated it, whose western margin crosses the Santa Fé road west of the Pawnee Fork; and of the Tertiary, Cretaceous and other strata on the way to Santa Fé; of the Geology of the vicinity of Santa Fé; of the Geology of the route from Santa Fé to the Sierra la Plata, including a description of the boiling spring of Pagosa, 40 to 50 feet in diameter, in apparent ebullition from escaping gases, situated on the San Juan, up the valley between the Sierra San Juan and the Sierra del Navajo; on the Geology of the Sage-Plain and Valley of the Upper Colorado, with an account of the cliff habitations; and on the region of the San Juan. Dr. Newberry describes and figures Triassic plants (*Otozamites*, *Zamites*, *Pecopteris*, *Pterophyllum*, *Podozamites*, *Alethopteris*, *Camptopteris*, *Tæniopteris*, and *Jeanpaulia*) from Los Bronces or Yaki River, Sonora, and from the copper mines near Abiquiu, New Mexico, besides some Carboniferous and Cretaceous fossils;

and Mr. Meek, various Cretaceous species. Dr. Newberry mentions that a larger species of Jeanpaulia has been observed by him among the plants of the Triassic of North Carolina.

It is greatly to be regretted that the publication of this excellent volume has been so long delayed.

4. *Report of Explorations across the Great Basin of the Territory of Utah, for a direct wagon-route from Camp Floyd to Genoa in Carson Valley*, in 1859, by Capt. (now Colonel) J. H. SIMPSON, Corps Topogr. Engineer, U. S. A. Engineers' Department, U. S. A. 494 pp. 4to, with plates and maps. Washington, 1876. Containing a Geological Report of Mr. HENRY ENGELMANN; Paleontological, of Mr. F. B. MEEK; Ichthyological, of Mr. T. GILL, etc.—The explorations here recorded were made in 1859, and the report now published bears the date Febuary 5, 1861—the delay in publication having been occasioned by the civil war.

The volume is occupied chiefly by the observations of the Engineer corps—including, the results of astronomical, topographical, climatal, magnetic and other related investigations, tables of distances, altitudes and grades of routes; but contains also a history of the explorations of the Great Basin from the time of Father Escalante in 1776 to the present period, and a general description of the country, with Captain Simpson's Itineraries; also a Geological Report, occupying 92 pages, by Henry Engelmann, geologist of the expedition, a Paleontological Report, of 40 pages, by Mr. F. B. Meek; and Appendixes on the Birds, by Prof. Baird, on the Fishes, by Mr. T. Gill, on the Botany, by Mr. G. Engelmann, and on Eastern Utah and its Indians, by Dr. G. Hurt. The delay in the publication of Mr. Henry Engelmann's valuable report has lost him the credit of first discovery in many points connected with the geology of the region. It treats of the geology of Eastern Kansas and Southeastern Nebraska; of the plains next west, to the foot of the Rocky Mountains; of the district of the Rocky Mountains, between Fort Laramie and the South Pass; of the Green River Basin, and the region west to the axis of the Wahsatch Mts.; the district of Central and Western Utah, the so-called Great Basin. Mr. Meek's report gives descriptions and figures of Devonian, Carboniferous, Jurassic, Cretaceous and Tertiary fossils, the illustrations occupying five plates. The Ichthyological Report of Mr. Gill is accompanied by eleven lithographic plates, and the Botanical Report of Mr. G. Engelmann, by three plates, illustrating the species *Echinocactus Simpsoni* Engelm. and *Opuntia pulchella* Engelm.

5. *Fossil marine plants from the Coal-measures.*—Mr. LESQUEREUX, in the Report of the Indiana Geological Survey for 1875, has described three species of sea-weeds of the Lower Silurian genus *Palæophycus* Hall, from iron concretions in a bed of clay over coal L, on a branch of Salt Creek, Vigo County, Indiana; also others of the new genera *Asterophycus* from a sandstone connected with coal-beds near New Harmony, Indiana, and from the Lower Carboniferous, Rock Castle, Kentucky, and *Conostichus*, from Port Byron, Illinois and from Indiana.

6. *Remarks on Fossils from the Ashley Phosphate Beds.*—Prof. Leidy observed that the so-called phosphate beds of Ashley River, South Carolina, were remarkable for the singular admixture of multitudes of fossils of different ages, from the early Tertiary period inclusive down to the present epoch. The phosphatic nodules, for which the beds are explored, appear to have had their origin from the Eocene rocks beneath. These have also contributed numerous remains of marine vertebrates, especially of squalodonts, reptiles, and fishes. Mingled in the sand and clay with the phosphatic nodules and bones of Eocene animals, are innumerable remains of cetaceans, sharks, and other marine animals of perhaps the middle and later Tertiary ages. Added to these are multitudes of remains of both marine and terrestrial animals of the Quaternary period. There are found pell-mell together bones of Eocene squalodonts, animals related to the whales and seals; hosts of teeth of the great shark *Carcharodon augustidens;* myriads of teeth of the giant of sharks of the Tertiary period, the *Carcharodon megalodon;* bones and teeth of whales and porpoises; and abundance of remains of elephant, mastodon, megatherium, horse, etc.; and occasionally the rude implements of our more immediate ancestors.

From among a collection of fossils from the Ashley phosphate beds, recently submitted to his inspection by Mr. J. M. Gliddon, of the Pacific Guano Company, the specimens were selected which lie upon the table. One of these is a well-preserved tooth of a Megatherium; another, a characteristic portion of the skull of a Manatee; a third, a complete tusk of the Walrus; indicating a still farther point south for the extension of this animal than had been previously known; fourth, a huge tooth of a cetacean allied to the sperm whale, probably the same as those from the crag of Antwerp ascribed to Dinoziphius. Besides these there are the beaks of three cetaceans of the little known family of the Ziphioids. These are porpoise-like animals, without teeth in the upper jaw, and usually with but a single pair of teeth in the lower jaw. The beaks, composed of the co-ossified bones of the face, are remarkable for their ivory-like density which probably rendered them available as weapons of defence.

A fourth beak from the same locality, presented by Mr. C. S. Bement, belongs to a different species of the same family. The beaks and some associated fossils will form the subjects of a paper shortly to be presented to the Academy.

The beaks have been referred to species with the following names and brief distinctive characters:—

Choneziphius trachops.—Supra-vomerian canal open. Intermaxillaries co-ossified and forming a crest along the middle of the beak extending to the interval of the prenareal fossæ. Maxillaries with a rugged tract at the upper part of the base of the beak.

Choneziphius liops.—Beak proportionately of less length than in the preceding. Supra-vomerian canal and intermaxillaries the

same, except that the crest of the latter in front is acute. Maxillaries without the rugged tract at base.

Eboroziphius cœlops.—A new genus as well as species. Beak above forming a broad gutter as in Hyperoodon, and not divided by an intermaxillary crest as in the preceding. Maxillaries with prominent lateral crests at base, convex inwardly. Right prenareal fossa occupied by a thick osseous disk. Intermaxillaries co-ossified. Supra-vomerian canal open.

Belemnoziphius prorops.—Beak solid, with all traces of the original separation of the constituent bones and the ossified mesethmoid cartilage obliterated.—*Proc. Acad. Nat. Sci., Philad.*, May 9.

7. *Fish Remains of the Mesozoic Red Shales.*—Prof. Leidy remarked that the remains of life were rare in the Mesozoic red shales which cross Pennsylvania about fifteen miles north of Philadelphia. Hence any fossils whatever from these rocks were of interest. The three cycloid fish scales, and a few detached caudal rays, in the fragments of red shales, presented by him this evening, he found on the Perkiomen Railroad, near Yerkes' Station, Montgomery County. One of the scales resembles those described by the late Prof. E. Emmons, under the name of *Rhabdiolepis elegans*, from the mesozoic coal shales of Chatham Co., N. C.—*Proc. Acad. Nat. Sci., Philad.*, May 9.

8. *A Study of the Rhætic Strata of the Val di Ledro, in the Southern Tyrol;* by T. Nelson Dale, Jr., Mem. Geol. Soc. de France. 70 pp. 8vo, with maps and sections. Paterson, N. J. 1876.—The author gives the results of his geological explorations in the Southern Tyrol, and illustrates his subject with a colored geological map and many sections.

9. *On the Mammalia and Traces of Man found in the Robin-Hood Cave;* by W. Boyd Dawkins.—The author noticed the various species of animals discovered by Mr. Mello during the researches, the results of which are given in another paper, and drew certain conclusions from their mode of occurrence as to the history of Robin Hood's Cave. He considered that the cave was occupied by Hyænas during the formation of the lowest and middle deposits, and that the great majority of the other animals whose remains occur in the cave were dragged into it by the Hyænas. That they served as food for the latter is shown by the condition of many of the bones. During this period the red sand and clay of the lowest stratum was deposited by occasional floods. The red loam or cave-earth forming the middle stratum was probably introduced during heavy rains. The occupation of the cave by Hyænas still continued, but it was disturbed by the visits of Palæolithic hunters. The remains found in the breccia indicate that the cave was inhabited by man, and less frequently visited by hyænas than before. The presence of vertebræ of the hare in the breccia would imply that the hunters who occupied the cave had not the dog as a domestic animal. After a discussion of the relations of the animals forming the fauna of the cave, the author

proceeded to describe the traces of man found in it, which consist of fragments of charcoal, and implements made of antler and mammoth-tooth, quartzite, ironstone, greenstone and flint. The distribution of these implements in the cave represents three distinct stages. In the cave-earth the existence of man is indicated by the quartzite implements, which are far ruder than those generally formed of the more easily fashioned flint. Out of 94 worked quartzite pebbles only three occurred in the breccia, while of 267 worked flints only eight were met with in the cave-earth. The ruder implements were thus evidently the older, corresponding in general form with those assigned by De Mortillet to "the age of Moustier and St. Acheul," represented in England by the ruder implements of the lower breccia in Kent's Hole. The newer or flint series includes some highly finished implements, such as are referred by De Mortillet to "the age of Solutré," and are found in England in the cave-earth of Kent's Hole and Wookey Hole. The discovery of these implements considerably extends the range of the Palæolithic hunters to the north and west, and at the same time establishes a direct relation in point of time between the ruder types of implements below and those more highly finished above.—*Proc. Geol. Soc., in Ann. Mag. Nat. Hist.*, Aug., 1876.

10. *Evidences of Theriodonts in Permian Deposits elsewhere than in South Africa;* by Prof. R. Owen.—In this paper the author noticed some described Reptilia which he believes to belong to his order *Theriodontia.* In 1838 Kutorga described as probably mammalian the distal end of a humerus showing a perforation or canal above the inner condyle. The specimen was from the Permian of the Western Ural; and Kutorga gave it the name of *Brithopus priscus.* Under the name of *Orthopus primævus* he described the proximal part of the humerus of the same species, perhaps of the same bone. There is thus evidence of an extinct reptile in the Permian deposits of the Ural with a humerus showing the characters of the Theriodont reptiles of the Karoo series of South Africa. The British Museum possesses a cast of the first-mentioned fragment, labelled by Krantz "*Eurosaurus Uralensis*, H. von Meyer, *Brithopus priscus*, Kutorga." The genus *Eurosaurus* was founded in 1842, by Fischer von Waldheim, upon some fragments of bone, including a humerus with a broad proximal end as in Kutorga's *Orthopus;* and Fischer also noticed a humerus showing characters like those of Kutorga's *Brithopus*, from the same locality as the portion of a jaw described under the name of *Rhopalodon Wangenheimii* Fischer, which contained nine molar teeth, with thick, pointed, subcompressed crowns, with trenchant and serrate borders. In 1858 H. von Meyer described a skull from the Permian of the Ural, under the name of *Mecosaurus Uraliensis*, as a Labyrinthodont; and Eichwald referred this genus, with Kutorga's *Brithopus* and *Orthopus*, to Fischer's *Eurosaurus.* The author regarded *Mecosaurus* as truly Labyrinthodont; whilst the Permian forms constituting Kutorga's genus he referred to the Theriodont order. From

the same locality as the above, Kutorga describes *Syodon biarmicum* as probably a Pachyderm. Its teeth resemble those of *Cynodraco*. Eichwald's *Deuterosaurus biarmicus* is founded upon the fore part of both upper and lower jaws of a reptile, containing teeth with denticulate or crenulate trenchant borders, the canines being large, especially in the upper jaw. *Deuterosaurus* closely resembles *Cynodraco*, and still more the *Lycosaurus* of the Karoo beds of the Sneewberg range. All the above are from the Permian beds of the Ural; and the author regards them as furnishing suggestive evidence of the Palæozoic age of the Karoo series, in which the Theriodont reptiles are best represented.

The author further notices a Theriodont allied to *Lycosaurus*, from a red sandstone, probably of Permian [Triassic?] age, in Prince-Edward Island. The remains include the left maxillary, premaxillary, and nasal bones; the teeth, implanted in distinct sockets, have subcompressed, recurved, conical, pointed crowns, with minutely crenulated borders. The foremost tooth in the maxillary is a canine; and in other points the dentition shows Theriodont characters This fossil has been described by Dr. Leidy under the name of *Bathygnathus borealis*. Thus, supposing the affinities of the fossils from the Ural and Prince-Edward Island to be correctly determined, the Reptilia distinguished by Mammalian characters are shown to have had a very wide range. Further, the author thinks that the Theriodont reptiles of the Bristol dolomitic conglomerate may also prove to constitute a family in the Theriodont order.—*Proc. Geol. Soc., in Ann. Mag. Nat. Hist.*, Aug., 1876.

11. *Silurian dioryte, chlorite slate and serpentine in Newfoundland.*—Mr. Howley's labors in Newfoundland during 1874 were, in accordance with Mr. Murray's plans, given to the survey, topographical and geological, of the western coast, about the peninsula and bay of Port-a-Port, and St. George's Bay. In tracing the Lower Silurian formations of the Newfoundland coast, Mr. Murray and his colleagues have been able to identify them with more or less precision as equivalents of the Quebec and Birdseye and Black River groups of Canada. But in the course of their surveys they have at different times encountered intercalated sheets of metamorphic rocks in the Lower Silurian series, overlying unaltered and fossiliferous strata. Thus, at Bonne Bay, in 1862, Mr. Richardson found highly metamorphosed rocks, including white talcose slates and serpentine, in some portion apparently of the Quebec group. Four years afterward Mr. Murray observed, farther south, in the Bay of Islands, that sandstones believed to represent the Sillery zone of the Quebec group passed below the serpentine of the Blowmedown Mountains. Mr. Howley has now confirmed and extended these observations by mapping the country between the Bay of Islands and St. George's Bay. He has traced Mr. Murray's serpentine rocks southward to Bluff Head, and finds that they pass unconformably over different horizons of rocks which are taken to represent the Sillery and Levis subdivisions of the Quebec group of the Lower Silurian system. The

striking character of this unconformable junction is well brought out upon the map, where two large cakes of the overlying rocks are seen to sweep over both anticlinal and synclinal folds of the lower formations. These cakes consist of brecciated dolomite or limestone, chlorite-slate, dioryte and serpentine, having a total thickness of perhaps 1,500 feet. Their exact geological horizon seems not yet quite satisfactorily fixed, but they are placed provisionally between the Sillery and Birdseye and Black River formations. Doubtless further details will be given in future reports regarding this remarkable feature of Newfoundland geology, and till they appear, it may be well to avoid any discussion of the theoretical aspect of the subject. It is not the first time that an instance has occurred of the higher rocks of a district being more metamorphosed than the lower, but there has probably never been observed so remarkable a case, for here the metamorphosed and contorted series is described as actually overlying unmetamorphosed strata.—*Notice of the Report on the Geological Survey of Newfoundland for* 1874, *in Nature of July* 20.

12. *Oldhamia in Wisconsin.*—In a letter to one of the editors of this Journal from Mr. J. W. Porter, dated Eau Claire, Wisconsin, June 12th, the writer states that he has found the *Oldhamia radiata* abundantly and very perfect in the vicinity of Eau Claire. In the bluff around this place there is a large exposure of Potsdam sandstone, quite fossiliferous, with numerous Trilobite impressions of several species, Pteropods and Lingulæ, besides Fucoidal impressions and wave marks. With the *Oldhamia radiata* occurs *Scolithus linearis*, and neither of them seems to extend as high as to the beginning of the other forms, or to the bottom of the sandstone exposures.

13. *Reef-building corals in the Tasmanian Tertiary.*—Professor P. Martin Duncan has described the new reef-building species *Heliastræa Tasmaniensis*, *Thamnastræa sera* and another species of Thamnastræa, from Cape Howe, Tasmania, 15° of latitude south of the present southern limit of the coral-reef seas in that part of the ocean.

14. *Carboniferous Pulmonates.* (From a letter to the editors, dated Montreal, July 24, 1876.)—In a recent visit to the South Joggins, in which I was assisted by Albert I. Hill, Jr., of the Cumberland Coal Mine, we succeeded in tracing *Pupa vetusta* to a higher level in the Coal formation than previously. A number of specimens were found in the material filling an erect Sigillaria in group XXVI of my section of the South Joggins, the same group in which Marsh's *Eosaurus* was found, and which has also afforded reptilian footprints. The bed is 222 feet above the main coal seam, 842 feet above the bed in which this shell was first discovered by Sir C. Lyell and myself, and about 2,000 feet above the lowest bed in which I have as yet found specimens. It thus appears that this little pulmonate continued to flourish in the Carboniferous swamps after its ancestors had been buried by 2,000 feet of sediment, including many beds of coal and nearly the

whole thickness of the productive Coal-measures. Its companion pulmonate, *Conulus priscus*, has as yet been found only in the lowest of the beds above referred to.

We were so fortunate as to discover, on the same expedition, another large Sigillaria stump, stored with reptilian bones; which it is hoped may afford some interesting additions to the land fauna of the Coal period. J. W. DAWSON.

15. *Brachiopods of the Swedish Paradoxides beds of Sweden.*—M. Linnarsson enumerates and describes the following Swedish Brachiopods (Swedish Acad. Sci., May 12, 1875): *Orthis Lindströmi* Linnarsson, *O. exporrecta* Linn., *O. Hicksi* Salt., *Lingulella* (?) *Nathorsti*, *Obolus* ——? *Acrotreta socialis* v. Seebach, *Obolella sagittalis* Salt., *Acrothele* (n. g.) *coriacea* Linn., *A. granulata*, *Kutorgina cingulata* Bill. var. *pusilla*, *Iphidea ornatella* Linn.

The Paradoxides and lower beds of Great Britain have thus far afforded only *Lingulella ferruginea* Salt., *L. primæva* Hicks, *Discina pileolus* Hicks, *Obolella sagittalis* Salt., *O. maculata* Hicks, *Orthis Hicksi* Salt., with perhaps *Kutorgina cingulata* Bill.

Including all *known* species, the number of species is small compared with that of the trilobites, the ratio being 29 to 150 of the latter. In general the Paradoxides beds are characterized by the most of their Brachiopoda having a corneous shell. The generic types *Kutorgina*, *Acrothele* and *Iphidea* have not been found in later beds.

16. *Geological Survey of Brazil.*—A recent letter to Prof. T. B. Comstock from Prof. C. F. Hartt, head of the Geological Survey of Brazil, states that he is preparing to send one division of his corps, probably under the direction of Mr. O. A. Derby, to make a careful examination of the Amazonian Country, and to connect the explorations of this region with those now in progress to the southward, in the interior of Brazil, and along the coast.

17. *Geological Map of Illinois.*—The geological map of Illinois, announced as nearly ready by Mr. Worthen in the last (sixth) volume of his Geological Report, has been published. It is of large size and well colored.

18. *Report on the Chemical, Mineralogical and Microscopical Characters of the Lavas of Vesuvius, from* 1631 *to* 1868; by Rev. SAMUEL HAUGHTON, of Trinity College, Dublin, and EDWARD HULL, Director of the Geological Survey of Ireland. 164 pp. 4to. 1876. Art. III of vol. xxvi, of Trans. R. Irish Acad., Dublin.—In this elaborate memoir the chemical and mineralogical part is by Dr. Haughton, aided in the chemical analyses by Mr. Wm. Early, and the microscopical, by Mr. Hull. The minerals found by the latter to be present in all the lavas, are leucite, anorthite, augite, magnetite and nephelite; in many of them, traces of sodalite, olivine, hornblende and mica; in several, sanidine, but this is rarely a prominent constituent; in a few, a little apatite. In the discussion of the chemical results with reference to the proportions of these mineral constituents, Dr. Haughton, by a simple

mathematical method, obtains the maximum and minimum of the amount possible for each constituent. The probable proportions of some of the constituents are then deduced from their relations in composition, and a mean possible value obtained for the rest. A comparison of the chemical composition of these minerals with the chemical composition of the lava, gives by subtraction, the chemical composition of the paste. The amount of paste is arrived at through the assumption that "*of the numerous possible solutions, that will be the occurring one in Nature which involves the largest amount of definite minerals and the least amount of indefinite paste.* Calculating from this basis, he arrives at the compositions of twenty Vesuvian lavas ejected at different times from 1631 to 1868, of which the following are examples:

	Gravina. 1631.	Granatello. 1631.	Della Scala. 1631.	C. de S. Vito. 1767.	C. de Salvatore. 1834.	The Atrio. 1855.	T. d. Greco. 1861.
Leucite,	38·2	33·6	40·6	41·4	39·7	36.8	34·2
Anorthite,	6·6	0·6	6·9	9·4	0·4	11·8	11·6
Magnetite,	7·14	4·45	4·9	6·9	9·7	3·35	3·74
Olivine,	tr.	tr.	tr.	tr.	tr.	tr.	----
Augite,	28·6	41·2	31·1	25·1	27·4	28·7	30·4
Hornblende,	tr.	tr.	----	----	tr.	tr.	----
Mica,	tr.	----	----	----	----	----	----
Nephelite,	10·5	10·0	6·5	8·6	11·2	11·5	10·9
Sodalite,	tr.	tr.	tr.	----	----	tr.	tr.
Apatite,	----	0.44	1·1	----	----	tr.	San.
Paste,	8·96	9·71	8·9	8·6	11·2	9·6	9·16
	100·00	100·00	100·0	100·0	100·0	100·0	100·00

The ingredients of the paste, as deduced by the method adopted, are silica, lime and protoxide of iron, and the mean composition, according to Dr. Haughton, corresponds to the formula 2RO, SiO_2, "which represents a very fusible basic glass, of a brownish color from the large quantity of iron protoxide." The order of formation of the minerals, according to Dr. Haughton's views, is first the potash and soda minerals, leucite and nephelite or sodalite; then the magnesia mineral, augite; and lastly magnetite and anorthite.

The analysis of the Vesuvian augite which is taken for the calculations is that of Wedding, of augite from a lava of 1631, giving only 4·54 p. c. of protoxide of iron; the analysis of Rammelsberg, of the augite from a Vesuvian lava of 1858, gave 9·08 FeO. The constituent augite—one of the four always present—is hence one source of uncertainty in such calculations, for the maximum deduced (the amount usually taken by Dr. Haughton in his final results) will differ widely in the two cases. Further, the CaO not used by augite belongs to anorthite, and therefore the proportion of anorthite would also be different. There is, hence, reason to suspect that the calculated percentage of anorthite in several of the tabulated results is below the actual amount present in the lavas.

19. *On the crystallographic relations of the three types of Chondrodite (Humite).*—M. DesCloizeaux in a recent letter, dated Paris, July 1st, 1876, gives the results of his researches in regard to the optical characters of chondrodite. These results are of especial interest as proving for the Swedish chondrodite, and the Vesuvian humite what has been shown by the writer to be true of the chondrodite from Brewster, N. Y.,—that the second and third types are monoclinic, not orthorhombic.

The principle conclusions of M. DesCloizeaux are, as follows.

The three types of humite, described by Scacchi, constitute three different species, closely related to each other in regard to form. The crystallographical and optical characters of the types are the following: Type I, humite from Vesuvius. Orthorhombic. Fundamental angles, as measured, *$A \wedge e^5 (pe^{\frac{1}{2}} = 001 \wedge 201) = 103° 47'$, $A \wedge i^2 (pa^3 = 001 \wedge 013) = 124° 16'$. The plane r^5 is made the fundamental pyramid with $A \wedge r^5 (pb^{\frac{1}{2}} = 001 \wedge 111) = 101° 39'$, and o^2 is made the unit prism, $B \wedge o^2 (100 \wedge 110) = 114° 50'$. Plane of the optic axes parallel to the base, with the acute bisectrix parallel to the shorter diagonal of the base. Dispersion weak, perhaps $\rho < v$; 2Hα (red rays) $= 78° 18' - 79°$.

Type II, chondrodite from Sweden. Monoclinic. Fundamental angles $A \wedge e^2 (ph = 001 \wedge 100) = 108° 58'$; $A \wedge i (pe^1 = 001 \wedge 011) = 122° 29'$; $C \wedge n^{2\prime} (g^1 h^3 = 010 \wedge 210) = 135° 41'$. The planes r^2 and r^3 are made the unit pyramids; $A \wedge r^2 (pd^{\frac{1}{2}} = 001 \wedge 111) = 125° 50'$, and $A \wedge r^3 (pb^{\frac{1}{2}} = 001 \wedge \bar{1}11) = 113° 28'$. Plane of the optic axes inclined to the front edge, and making an angle of about 30° with the base. The crystals, mostly twins, composed of hemitropic bands parallel to the base; two collections of these bands were observed in one crystal united by an irregular line not referable to any plane on the crystal. The number of these twinning bands varies with every specimen examined. Apparent axial angle (in oil), red rays, 86° 27′, blue, 86° 38′. Bisectrix positive, normal to the plane of symmetry. Dispersion also *crossed* (tournante). In several other crystals the axial angle was found to vary from 86° 14′ to 87° 20′.

Type III. Humite, color pale yellow, from Mt. Somma. Monoclinic. Fundamental angles; $A \wedge e^4 (ph' = 001 \wedge 100) = 100° 48'$; $A \wedge i^2 (pe^1 = 001 \wedge 011 = 125° 13')$; $C \wedge r^8 (g^1 m = 010 \wedge 110) = 154° 48'$. The planes r^4 and r^5 are taken as the unit pyramids: $A \wedge r^4 (pd^{\frac{1}{2}} = 001 \wedge 111) = 125° 47'$, $A \wedge r^5 = 001 \wedge \bar{1}11) = 119° 17'$. Plane of the optic axes inclined to the front edge and making an angle of about 11° with the base. Dispersion of the axes feeble $\rho < v$. Dispersion also crossed, scarcely appreciable. Bisectrix positive, normal to the plane of symmetry. Axial angle (in oil), red rays, 84° 38′–85° 4′. The white crystals, which are in appearance

* The letters given are those of Scacchi, the symbols which follow are those of DesCloizeaux, in his own and in Miller's method of notation.

simple, are mostly complex, being composed of parallel hemitropic bands. A yellow crystal, on the other hand, cut parallel to the plane of symmetry, showed a method of twinning analogous to that observed by Scacchi; it was composed of *five* individuals.

M. DesCloizeaux has also made an important observation tending to explain the well known variation in the composition of the three types. A small crystal, apparently of the first type, sliced, and examined optically, showed that it was penetrated irregularly by a crystal of the third type. M. Des Cloizeaux concludes from this that the former analyses cannot be considered reliable, and that the true composition can be obtained only from crystals which have previously been subjected to an optical examination. The second type seems to be the most homogeneous, and the one whose composition has been most certainly determined.

For the sake of comparison the results obtained by the writer from an optical examination of the chondrodite from Brewster, N. Y. (this Jour., III, x, 89, Aug., 1875, and xi, 201, Feb., 1876) are here cited. It will be seen that those since obtained by Des Cloizeaux for the chondrodite of Sweden and humite of Vesuvius agree very closely with them.

Type II, monoclinic; angle made by plane of optic axes with the base 25° 50′ (about 30°, DesCloizeaux). Bisectrix positive, normal to the plane of symmetry, $2H\alpha$ (red rays) $=88° 48'$ (86° 14′ -87° 20′, DesCloizeax).

Type III, monoclinic; angle made by the plane of the optic axes with the base about 7½° (11° DesCloizeaux, humite).

The measured angles upon the Brewster crystals, as was stated, were inconclusive except as proving that the obliquity did not exceed a very few minutes. How small the variation from the rectangular form is for crystals of the second type, as given by DesCloizeaux, may be judged from the following pairs of angles: $A \wedge e^2 = 109° 5'$, $A \wedge e^{2\prime} = 108° 58$; $A \wedge r^3 = 113° 28'$, $A \wedge r^{3\prime} = 113° 25'$, etc.; if the crystals were orthorhombic, as has been assumed, the planes e^2 and $e^{2\prime}$ would be identical, and the angles on the base A would be the same; so also for r^3 and $r^{3\prime}$. In the third type DesCloizeaux makes the monoclinic variation from the rectangular form about *two* minutes. Some additional crystals of the second type of chondrodite recently obtained from Brewster, N. Y., offer an opportunity to test by accurate measurement the amount of the obliquity for the species, which the writer will not fail to avail himself of at an early date. E. S. DANA.

20. *Die Mineralien Badens nach ihrem Vorkommen*, von GUSTAV LEONHARD. 3d ed. 65 pp. 8vo. Stuttgart, 1876.—The Grand Duchy of Baden is remarkable for the variety and abundance of the minerals which it affords. This is explained, as remarked by Prof. Leonhard, by the wide range of rocks found in the country, embracing not only the older crystalline rocks with their many metallic veins, but also a large variety of igneous rocks, of which those of the Kaiserstuhl are especially rich in minerals, and also a considerable series of sedimentary rocks. The descriptions of

the individual minerals by Prof. Leonhard are concise and yet complete, and doubtless the work will prove highly valuable to those who have occasion to use it. E. S. D.

21. *Studien über Mineral-Pseudomorphosen. Inaugural-Dissertation* von F. E. GEINITZ. 56 pp. 8vo. Stuttgart, 1876.—Dr. Geinitz has subjected a large number of pseudomorphs to a careful study, particularly by means of the microscope, and the results of his work will be read with interest. The pamphlet is illustrated by a plate with a series of figures.

22. *New Minerals.*—Prof. C. U. SHEPARD has named and partially described the following new species:

Vanuxemite. Occurs in small irregular patches scattered through a firm ochery aggregate, proceeding from the decomposition of several zinc ores. Massive, impalpable, with an even or conchoidal fracture. Color white, dull. H.$=2{\cdot}5-3$, G.$=2{\cdot}5$. Does not adhere to the tongue, but emits a feeble clayey odor on being breathed upon. B. B. fuses readily to an opaque enamel. Composition SiO_2 35·64, $\text{A}lO_3$ 11·70, ZnO 32·48–36, H_2O 14·80–19·88$=$99·70. Locality, Sterling Hill, N. J.

Keatingine. Considered "probably a new species." Closely resembles fowlerite in crystalline structure, but angles obtained on cleavage prisms 64° and 116°. Does not lose luster on weathering. H.$=4{\cdot}5-5$, G.$=3{\cdot}33$. B. B. fuses to a reddish semi-transparent glass. Composition SiO_2 47·8, MnO 27·7, ZnO 5·6, CaO 18·0, H_2O 0·8$=$99·9. Locality, Franklin, N. J., where it was found in a mass of yellow garnet.

Calcozincite. Massive, fine-granular; interpenetrated with fibres of asbestus and sussexite. Luster vitreous. Color light orange-red. Streak lemon-yellow. Translucent. H.$=3{\cdot}5$, G.$=3{\cdot}95$. Effervesces slightly with acid. B. B. blackens. Composition ZnO 81·00, CaO 7·56, CO_2 5·80, H_2O 4·26, MnO tr$=$98·62.

Euchlorite. Massive, in coarse elongated scales. Color light olive-green. Powder pale green. Luster subpearly. H.$=2{\cdot}5-3$, G.$=2{\cdot}71$. B. B. fuses with difficulty on thin edges to a greenish-gray enamel. Decomposed by sulphuric acid. Composition SiO_2 35·51–38·46, $\text{A}lO_3$ 6·80, FeO 15·52, (MgO 38·07), H_2O 6·10, 100. Locality, Chester, Mass., where it occurs in a layer on both sides of an extensive vein of albite.

Pelhamine. Forms irregular seams and masses sometimes a foot thick at the asbestus mine at Pelham, Mass. Resembles a black serpentine closely. Almost without luster. Powder dark greenish-gray. H.$=5{\cdot}0$, G.$=2{\cdot}9-3{\cdot}2$. B. B. infusible. Composition SiO_2 38·40, $\text{A}lO_3$ 2·80, FeO 15·52, (MgO 39·88), H_2O 3·40 $=$100.

Prof. Shepard has also published a catalogue (8 pp.) of the minerals found within seventy-five miles of Amherst College, Mass. E. S. D.

III. Botany and Zoology.

1. *The Structure and Movements of the Leaves of Dionæa muscipula;* by Casimir De Candolle.—A neat paper, separately issued from the Geneva *Archives des Sciences Phys. et Nat.*, April, 1876, illustrated by two plates of anatomical details. One noteworthy suggestion—which has already been made here,—is that the sudden change of electrical current at the closing of the trap, ascertained by Burdon Sanderson (and much insisted on, on account of its accordance with what takes place in muscular motion), may have had its importance much overrated. The electro-capillary currents, which Becquerel long ago demonstrated in vegetable tissues generally, would almost necessarily be influenced in some such way by the displacements of liquid which would accompany any such abrupt change in the turgescence of the parenchyma. In some experiments made three years ago by Professor Trowbridge, of Harvard University (which, unfortunately, were not followed up), it was found that the strong bending of an internode of stem, without lesion, produced a similar electrical effect.

M. Casimir De Candolle fairly deduces from his experiments the conclusion that animal matter is not necessary to the development and vigor of *Dionæa.* He goes on to the conclusion that the animal matter of the insects caught is not directly utilized by the leaves. This does not follow. Very much evidence would be required to rebut the presumption that the organic matters absorbed are somehow (and even directly) utilized by the plant.

The independent movement of the border of the trap with its fringe of bristles is explained by the anatomical structure, which is, as it were, distinct from that of the main body. The glands are stated to belong to the epidermis only; but the excitable bristles are connected by the cellular bulb with the subjacent parenchyma, so that impressions upon the former may readily be transmitted to the latter. The closing of the trap results from the comparatively permanent elastic tension of the largely fibrous external part of the leaf. It opens by counter-action of the parenchyma of the upper or inner side, through turgescence; the closing results from the sudden diminution of the turgescence, in some unexplained way. In other words, the trap is held open, and at the proper moment is let go. A. G.

2. *Diatoms in Wheat-straw.*—The article by Professor P. B. Wilson, in this Journal, for May last, is referred to in Trimen's Journal of Botany for July, with the remark that the asserted discovery "is not very likely to meet with acceptance among botanists." The real nature of the siliceous molds or casts which Professor Wilson took for diatoms must have suggested itself to those familiar with such matters, and would have been indicated to the author of the communication if this had happened to receive attention before insertion. A. G.

3. *An Intoxicating Grass.*—Besides the "Dronk" grass, i. e., Drunk Grass, of the Dutch Colonists in S. Africa, of which we mentioned Dr. Shaw's account a year or two ago, it now appears that there is in Mongolia another grass with a corresponding native name and similar properties. The account of it is given by Dr. Hance, in the July number of Trimen's Journal of Botany, from specimens and information supplied by Dr. Bretschneider, of the Russian legation at Peking. It proves to be a new species of *Stipa*, brought from the Alachan mountains by a Roman Catholic Missionary, whose horses were disabled by its inebriating properties. The wandering Mongols of the region are familiar with this grass, and use vinegar as an antidote. A. G.

4. *Primitiæ Monographiæ Rosarum.*—The third fascicle of this interesting essay by M. CRÉPIN has come to hand. It deals with Asiatic Roses, and throws much light upon them. Our Cherokee Rose is recognized as of Chino-Japanese origin; but he proposes—apparently with reason—to retain Michaux's name of *Rosa lævigata*, on the ground that this cannot have been the original *R. Sinica.* If not, the name *R. lævigata* has priority. *R. acicularis* of Siberia is recognized as a N. American species of high northern regions; where also *R. Davurica* and *R. amblyotis* (one or both) also appear to occur. A classification of the *Cinnamoneæ* Roses is given; in which *R. alpina* and *R. blanda* belong to the series *Subinermes; R. stricta* and *R. acicularis* to the *Aciculares; R. Woodsii*, *R. Californica*, *R. laxa*, *R. cinnamonea*, and *R. amblyotis*, to the *Diacantheæ.* A. G.

5. *Does the Age of a tree influence the time of Leafing?*—Every one knows that very young trees in a nursery are apt to come rather earlier into leaf than full-grown trees of the species. But this is explained by the nearness to the ground and consequent higher temperature. The comparison should be made between the oldest available trees and other well-developed trees of moderate age. M. Alph. De Candolle caused observations of this kind to be made in two old botanic gardens, viz: those of Paris and of Pisa; and the results were negative,—in the Paris cases no difference; in the Pisa cases, an old Gingko and an old Walnut tree leafed earlier than young trees of the species, while the old tree of Horse-chestnut, *Sophora*, Linden, and *Pawlownia* were later than the young trees. A very full series of cases, of different species, would be needed for the elimination of individual peculiarities, often great in this respect. But M. De Candolle is able to refer to better data, viz: to one case in which the date of coming into leaf of a Horse-chestnut tree, has been carefully recorded for sixty-eight years, and another for fifty-seven years; both at Geneva. Of course any differences due to age would be small in comparison with those due to climate, yet they might be expected to be sensible in the long series of years, if age really made any difference. But the figures do not bring to view any tendency to either earlier or later leafing with the advance of years. M. De Candolle's notice is in the *Archives des Sciences de la Bibl. Universelle*, June, 1876. A. G.

6. *Practical Botany, Structural and Systematic; the latter portion being An Analytical Key to the wild Flowering Plants, Trees, Shrubs, ordinary Herbs, Sedges and Grasses of the Northern and Middle United States, east of the Mississippi*; by AUGUST KŒHLER, M.D., Professor of Botany in the College of Pharmacy of the city of New York. 400 pp., 12mo, copiously illustrated. New York. 1876. Henry Holt & Co.—The structural portion of the work occupies ninety-three pages, and is apparently very well worked up. A glossary of eighteen pages follows. The remainder of the volume is a key, which—ignoring classes, orders, and the like, and little mindful of the integrity of genera—leads directly to genus and to species when these are given, and is intended to serve the purpose of a flora or manual. It is on the dichotomal mode; the first couplet distinguishes *Phænogams* from *Cryptogams;* the former are at once divided into those which have flowers inclosed in an involucre, and those which have not; to the former only *Compositæ* are referred—one sees not why. Those without an involucre to several flowers divide next into perfect and diclinous flowers (which is a very variable matter), and so on. A lady botanist of advancing years, who was brought up under the Linnæan system, used to boast that she could find out the name of a plant by that in half the time required to do it through the natural system of classification. We could not gainsay the fact, and it would have been hardly polite to tell her that she knew little more of botany after the operation than before. The Linnæan system, however, is, if we mistake not, a better, and perhaps a surer one than the present substitute. A. G.

7. *Flora of Southwestern Colorado;* by T. S. BRANDEGEE. Reprinted from Hayden's Bulletin of the Geological and Geographical Survey of the Territories, vol. ii, no. 3.—A small pamphlet, containing an excellent contribution to our Botany. In six pages the character of the country and its vegetation along the San Juan, the Mesa Verde, and the sub-alpine neighboring higher regions, is succinctly and clearly sketched, and the dominant plants mentioned. "The Mesa Verde, a plain of 200 square miles, raised nearly a thousand feet above the surrounding country, is a prominent topographical feature of southwestern Colorado. Its surface is perfectly dry, the showers from the La Plata mountains rarely wetting it except upon the northern edge. *Juniperus occidentalis* covers almost the whole mesa, and it is to the abundance of this ungraceful bushy tree that the name of the green mesa is due." "The sub-alpine *Coniferæ* of the southwestern slope are mainly *Abies Engelmanni* and *grandis.* These two species, either together or in forests of one alone, cover the western slope down to the altitude of *Pinus ponderosa*, 9,000 feet, both species large and magnificent trees. *A. Engelmanni* is the only conifer found at the timber line. . . . *Abies concolor* was not seen upon the western slope, and not a tree of *A. grandis* could be found on the eastern slope. *Pinus ponderosa* is abundant at 8,000 feet altitude, and its large trees will furnish a great amount of lumber. *P.*

flexilis is not common; it grows at 8,500 feet, with *P. ponderosa*, *Abies grandis*, *Menziesii*, *Engelmanni* and *Douglasii*, all associated at this altitude." "*Pinus edulis* is said to fruit once in seven years." "The number of phænogamous plants growing in southwestern Colorado will not equal the 900 species that can be found on any similar area of the eastern slope. The impressions received by any one who has noticed the flora of the eastern slope, riding rapidly over southwestern Colorado, below 8,000 feet altitude, are: the great scarcity of all vegetation, the comparative abundance of rosaceous shrubs and *Artemisia tridentata* [sage-bush], the great number of the annual species of *Eriogonum*, the showy blossoms of *Malvaceæ*, and the few species of *Astragalus* and *Pentstenon*. Nevertheless, the characters of four new *Astragali* appear in the accompanying list, and of other new species the number is considerable. A. G.

8. *Darwiniana: Essays and Reviews pertaining to Darwinism;* by Asa Gray. 396 pp. 8vo. New York: 1876. (D. Appleton & Co.)—The first two of the "Essays and Reviews" here collected into a volume, appeared in this Journal in 1860, not long after the publication of Darwin's first work, on the Origin of Species; and the others, subsequently, in this or other Journals of the country, excepting two, which are here first published. The chapters contain a clear exposition of the essential points in "Darwinism," and a discussion of the bearings of evolution-theories on Natural Theology, besides also a full review of the researches of Darwin and others on the subjects of Insectivorous and Climbing plants. The earlier articles were prepared in order to bring before American scientific readers the views set forth in Darwin's first work—not to advocate them; and, throughout the pages, as in all Dr. Gray has written on the subject, there is perfect fairness to both sides of the question. His extensive acquaintance with the plants of the world, and his oft-repeated perplexities—like those of other botanists—over the close relations among the species of some groups, and the difficulty of finding limits to variation, had prepared his mind for a discussion of any theory that might afford light and aid. His exposition of Darwinism was, therefore, the work of one ready to appreciate Darwin's facts and arguments, and ready to withhold assent if they were not satisfactory. In his paper of 1861—Chapter III—he says: "We are not disposed or prepared to take sides for or against the new hypothesis."

The next essay in the series published in 1863, presents some classes of facts connected with variation among plants, and indicates the "set and force of the current" toward a theory of derivation both in the facts and in the author; and the following essay—Chapter V—on the relations of North American to Northeast Asian vegetation, and of both to the Tertiary vegetation of the Arctic regions, first brought out in 1872, in his Address before the American Association, is an argument for the derivation of species from species, offering many strong facts in favor of the

derivation of the modern vegetation of the continents, by some method of variation, from Tertiary species.

At the same time, in the first as well as others of the essays, and especially in the seventh and the last, Dr. Gray argues, with the earnestness of personal faith, against Atheistic evolution, and in favor of design, or a divine purpose, in and throughout nature.

The work is commended to all readers who would understand what Darwinism in its essential features is, and who desire to learn, from one who knows all sides of the question, the relations of the subject to Natural Theology. J. D. D.

9. *Note on Gigantic Cephalopods,—a Correction.* By A. E. Verrill.—In describing the large Cephalopods from Newfoundland in two former articles,* a serious mistake was made by me in respect to the lingual ribbon, or odontophore, of the specimen (No. 5) of *Architeuthis monachus.* (See this Journal, vol. ix, p. 128, Pl. iv, fig. 6.) The organ described and figured as the odontophore proves not to be that organ, but is doubtless a specialized chitinous portion of the lining of the mouth or pharynx, covered with sharp chitinous teeth and hard granules. The precise original position of this armed membrane I have not yet been able to determine, owing to the mutilation of the adjacent parts before the specimen came into my possession, and my error was largely due to the mutilation, for the armed band described was not adherent except by a slight attachment at one end, and it occupied nearly the position in which the odontophore should have been situated. Nevertheless I was fortunate enough to find, several months after my papers were printed, the genuine *odontophore* among the dirt and debris that had remained in the bottom of the can in which the specimen had originally been sent from Newfoundland. This odontophore is about 70mm. in length, with the dentigerous portion, where widest, about 12mm. in width. The teeth are in seven rows, with an exterior row of small unarmed plates on each side, thus conforming to the arrangement in the other ten-armed cephalopods. The teeth are deep amber-colored and not unlike those of *Loligo* and *Ommastrephes* in form. Those of the median row have three fangs, the central one longest; those on the next row, on either side, have two fangs; while those of the two outer lateral rows on each side are simple, acute and strongly curved. A full description and figures, which have hitherto been delayed by an unusual pressure of other work, will soon be published in this Journal.

In this connection I wish also to record the occurrence of another gigantic species of cephalopod discovered by Mr. W. H. Dall, on the coast of Alaska. He found three specimens thrown upon the beach in April and May, 1872, and made some very valuable drawings of them while fresh He also preserved the pharynx, beak, odontophore, part of the "bone," and portions of the arms of one of the specimens, and has generously placed them in

* This Journal, vol. ix, 1875, pp. 123, 177. Also American Naturalist, vol. ix, Jan. and Feb., 1875, pp. 21, 78.

my hands for examination, together with his drawings, measurements and notes. The largest specimen had a total length of 14 feet, but the ends of the tentacular arms had been destroyed; length from tail to root of arms, 102 inches; to front edge of mantle, 91·5 inches; width across fins, 42 inches; diameter of body, 18 inches; slender portion of tentacular arms remaining, 61 inches; diameter, 2·5 inches; shorter arms (ends and suckers gone), 30 to 40 inches; diameter of eyes, 1·25 inches; length of pen, 89 inches. The eyes were furnished with lids. The few suckers remaining on some of the shorter arms of one specimen were alternate in two rows and agree with those of *Ommastrephes.* The color was reddish, in fine red dots on a white ground, a darker stripe on the outer median line of the arms. Tail acutely pointed. For this species Mr. Dall has proposed the name of *Ommastrephes robustus.* It is probably a genuine *Ommastrephes*, or if not, it is at least an extremely closely allied genus. I hope soon to publish detailed descriptions and figures of this very interesting species, which forms part of the exceedingly valuable collection made by Mr. Dall on the coast of Alaska.

10. *Comparative Zoology, Structural and Systematic;* by James Orton. New York: Harper & Brothers. 8vo, 384 pp. 350 wood cuts. 1876.—In the preface to this work the author states that "It is designed solely as a manual of instruction. It is not a work of reference, nor a treatise. So far as a book is encyclopediac, it is unfit for a text-book. This is prepared on the principle of 'just enough and no more.' It aims to present clearly, and in a somewhat new form, the established facts and principles of Zoology. All theoretical and debatable points, and every fact or statement, however valuable, which is not absolutely necessary to a clear and adequate conception of the leading principles, are omitted."

Probably very few, if any, zoölogists will admit that the author has succeeded in carrying these ideas into practice, and many may doubt whether, in some cases, failure in this respect may not have been more desirable than success. To have excluded all that is "debatable" or "theoretical" would certainly have very much reduced the size of this volume. And certainly "just enough and no more" is far from applicable to many chapters. The book is in most respects not unlike other similar compilations, and with about the average number of errors and inaccuracies, many of which will doubtless disappear in a second edition, but should have been avoided in the first. More than half of the volume is devoted to the general facts and principles of comparative anatomy and physiology, some portions being treated with perhaps unnecessary fullness, while others of more general importance and interest (e. g., reproduction and embryology) are treated with unnecessary brevity and reserve, due perhaps to the fact, as stated in the preface, of its "being fitted for High Schools and Mixed Schools by its language and illustrations." How far this consideration should be allowed to interfere with a clear statement of the

fundamental facts of biological science is a question upon which teachers are not likely to agree at present. The system of presenting the comparative anatomy before the systematic zoology is a practice by no means new in text books, and one that has its disadvantages as well as its advantages. An intermediate course has been found preferable by the writer. This book is profusely illustrated, but we regret to notice that very few, if any, of the cuts are new, many of them having done much service before in several text books and popular treatises, while a very large proportion have been borrowed from European books, and illustrate foreign animals, even when far better figures of corresponding American species are easily available. Formerly, when but few of our American animals had been well figured, there was some excuse for borrowing and copying the figures of European animals, but the case has been entirely changed within twenty years, for the American species are now very well and very fully figured in numerous works. Prof. S. Tenney has, in this respect, set an excellent example in his Manual of Zoology, where the figures are excellent and mostly from the standard works on American Zoology. It is to be presumed, however, that this glaring defect is to be attributed far more to the publishers than to the author of the present work. The false economy which so often impels American publishers to borrow for text books stale foreign cuts instead of employing fresh and useful ones, drawn from native animals, should be discountenanced by every naturalist. V.

11. *Geographical Variation among North American Mammals, especially in respect to size. Sexual, individual and geographical variation in Leucosticte tephrocotis.* By J. A. Allen. Extracted from the Bulletin of the Geological and Geographical Survey of the Territories, Vol. II, No. 4.—In the former paper Mr. Allen contributed a great amount of information on the variation of many of our larger mammals. His conclusions are largely based upon a study of the very large series of skulls belonging to the Smithsonian Institution. He shows that while most northern and Arctic animals decrease in size southward, the reverse of this is true of other species having a southern distribution, and that the same holds good for genera and families as well as for species.* Mr. Allen, in this paper, reverses some of his opinions, expressed in former papers, respecting the identity of some of the North American Mammals with those of Europe. He now admits that the common black bear (*Ursus Americanus*) is a species distinct from the brown bear (*U. arctos*) of Europe, but he states that the barren ground bear is identical with *U. arctos*, and considers the grizzly bear a "subspecies" of the latter. He now admits the American sable to be distinct from all the European forms. The common red fox he considers a "subspecies" of the red fox of Europe. He questions the specific distinctness of the Canada lynx from the bay lynx (*L. rufus*) and regards it as probably only a "subspecies."

* Similar laws have been found by us to hold good for the marine invertebrates of our coasts.

In the second paper the author shows that in all the American species of *Leucosticte* there is really considerable sexual variation, both as to size and color, and that the species also vary geographically. v.

12. *Archivos do Museu Nacional do Rio de Janeiro.* Vol. I. 1st Trimestre. 30 pp. 4to. 1876.—The first number of this new periodical is handsomely printed and illustrated. It contains valuable papers on Brazilian archeology, by Prof. C. F. Hartt, and by Carlos Wiener. v.

13. *Études sur les Echinoïdées*, par S. LOVEN, from Kongl. Svenska, Vetenskaps-Akad. Handligar. Vol. ii, No. 7. 4to, with 53 plates. 1875.—This very important work, although published some time ago, has only just reached us. It is mainly devoted to a very thorough and complete study of the skeleton and external organs of the entire group of Echini. A few new forms are also described and figured. v.

14. *Bulletin of the United States National Museum.* No. 5. *Catalogue of the Fishes of the Bermudas*, by G. BROWN GOODE; No. 6. *Classification of the Collection to illustrate the Animal Resources of the United States*, by G. BROWN GOODE. 1876.—The former is a very useful contribution to the Ichthyology of Bermuda and our own adjacent waters. It includes descriptions of many species from life, the synonymy, local names, etc.

The second work is a very comprehensive scheme, showing the possibility and manner of making such a collection complete. This system of classification has been carried out in the extensive collections illustrating this department in the Government Building of the Centennial Exhibition. v.

15. *Contributions to the Natural History of Kerguelen Island, made in connection with the U. S. Transit of Venus Expedition*, by J. H. KIDDER, M.D. Part II. May, 1876.—This final part contains the Oology, by J. H. Kidder and Dr. Elliott Coues; Botany, the Phænogamia, Filices and Lycopodiaceæ, revised by Prof. A. Gray, the Musci, by Thos. P. James, the Lichens, by Prof. Edw. Tuckerman, the Algæ, by Dr. W. G. Farlow; Geology, including a list of the rocks and minerals, by Dr. F. M. Endlich; Mammals, by Dr. Kidder; Fishes, determined by Prof. Theodore Gill; Mollusks, by W. H. Dall; Insects, by Dr. Kidder, the Diptera having been determined by C. R. Osten Sacken, and the Neuroptera, by Dr. H. A. Hagen; Crustaceans, by Prof. Sidney I. Smith; Annelids and Echinoderms, by A. E. Verrill; Notes on the specimens obtained, by Dr. E. Kershner and Mr. I. Russell, in New Zealand, etc., including minerals, birds, fishes, skulls, hydroids, etc.; and finally, an important study of the comparative anatomy and affinities of *Chionis minor*, by Dr. Kidder and Dr. Coues. The authors constitute a new tribe (*Chionomorphæ*) to include this species and *C. alba.* They also think it necessary to place the former in a new genus (*Chionarchus*). They regard this small and peculiar group as representing an ancient or ancestral type intermediate in some respects between the modern gulls

and plovers. Among the mollusks, Mr. Dall, in addition to other useful matters, describes a new species of *Lepton* (*L. parasiticum*) which lives upon the test of the sea-urchin (*Tripylus cordatus* V.), chiefly along the ambulacra near the mouth; a new genus and species, *Kidderia minuta*, related to *Modiolarca;* and a new genus and species of Chitonidæ (*Hemiarthrum setulosum*) is contributed by Dr. P. P. Carpenter. Mr. Dall also gives a new generic name (*Eatoniella*) to the small Rissoidæ described by Mr. E. A. Smith under the preoccupied name, *Eatonia.* Among the insects, new facts concerning the remarkable wingless diptera are given, and Dr. Hagen has described a new form (*Rhyopsocus eclipticus*). Among the crustaceans, Prof. Smith has described, as new, *Hyale villosa* and *Lysianassa Kidderi*, and as doubtful, *Atylus*(?) *australis* Miers(?), and gives useful notes on other species. Among Annelids, *Nereis antarctica* and *Neottis spectabilis*,* are described as new, with a revision of the characters of the latter genus. Among Echinoderms, *Pentactella lævigata*, *Hemiaster cordatus*,† *Asterias rupicola*, from Kerguelen Island, and *Astrophyton australe* from Tasmania are described as new, while *Ophioglypha hexactis* Smith is also fully described. Of Anthozoa, two species, *Anthopodium australe* V., new sp., and *Primnoella Australasiæ* Gray, both from New Zealand, are described. V.

V. Miscellaneous Scientific Intelligence.

1. *Elements of Physical Manipulation;* by Edward C. Pickering, Prof. Physics Massachusetts Institute of Technology. Part II. pp. x, 316, 8vo. New York, 1876. (Hurd & Houghton.)—In preparing this volume as a completion of the work of which the first part was published three years ago, the author has greatly extended the range of subjects treated, and has included in this portion topics belonging to a number of kindred branches of science. The first 108 pages are devoted to experiments illustrating electricity and heat, with descriptions of the apparatus required and the modes of conducting the various researches. Then follow chapters upon mechanical engineering, meteorology, practical astronomy and lantern projections. At the end are three

* In the Annals and Magazine of Natural History, April, 1876, p. 318, Mr. W. C. McIntosh has published descriptions of several Kerguelen Annelida from the English expedition. The *Nereis Eatoni* described by him, may, perhaps, be the same as our *N. antarctica*, or a sexual form of it; and his *Neottis antarctica*, may be identical with our *N. spectabilis*, but his descriptions are not sufficiently detailed to permit an accurate determination of these points. The tube of his *Neottis* appears to be quite unlike that of ours, but this may be due to difference of locality. Although this part of Dr. Kidder's report had been in type and the proof had been corrected several months previous to its publication, early in May, the paper by Dr. McIntosh has priority of actual publication.

† Mr. A. Agassiz has published, in the Proceedings of the American Academy, an interesting paper on the young stages of this species, found by the writer inhabiting the deep ambulacral furrows of the female specimens, where they were effectually concealed and defended by the longer spines projecting inward from the borders.

appendices, in the first of which certain topics in electricity are treated more fully than in the main portion of the volume, with the addition of a number of important matters pertaining thereto. The second contains a variety of tables and data useful in physical computations. The third is made up of general directions with reference to physical laboratories, a valuable list of works of reference, and an excellent collection of additional experiments, of varying difficulty, and some of them fitted to tax the skill of the best trained student. The same practical good sense is displayed in the selection and arrangement of the subjects as in the first part, and the two volumes constitute not only a very important contribution to the resources of the student, but also an invaluable aid to instructors in physical science. The cuts which accompany the text, though sufficient for the purposes of illustration, are hardly consistent in quality with the rest of the work, and if, in the endeavor to attain clearness and conciseness, the ordinary graces of style have been sometimes sacrificed, the reader will count it no serious imperfection in view of the very substantial excellence of the work. A. W. W.

2. *Treatise on the Mechanical Theory of Heat, and its applications to the Steam Engine, etc.;* by R. S. McCulloch, Civil Engineer and Professor of Mechanics in Washington and Lee University, Va. pp. xii, 288, 8vo. New York, 1876. (Van Nostrand.) —This volume contains a clear and simple mathematical exposition of the modern theory of heat, with many of its applications in practical matters, especially to the steam engine and other machines for the generation of power by means of heat. It begins with an historical sketch, giving an account of the various steps by which the mechanical theory of heat has been developed, and the historical method is kept in view throughout the book. The author in his preface "acknowledges his indebtedness to the profound views of his friend, Prof. W. H. C. Bartlett, whose mathematical exposition of the unity of physical action has been the point of departure of his own labors." A. W. W.

3. *On the Theory of Ventilation;* by F. S. B. Francois de Chaumont, M.D.—In my previous paper (Jan. 28th, 1875) I endeavored to establish a basis for calculating the amount of fresh air necessary to keep an air-space sufficiently pure for health, taking the carbonic acid as the measure. The results showed that the mean amount of carbonic acid as respiratory impurity in air undistinguishable by the sense of smell from fresh external air was under 0·2000 per 1000 volumes. My object in the present note is to call attention to the relative effects of temperature and humidity upon the condition of air, as calculated from the same observations.

Temperature.	Humidity.	Carbonic acid.
63° F.	73 per cent.	0·1943 per 1000 volumes.

If, now, we arrange the observations according as they differ from the above standard of temperature and humidity, and note the record of sensation attached to each, we may ascertain how far

the said record departs (if at all) from what it ought to have been as calculated from the actual CO_2. To do this we may employ the numerical values of the different classes, taking No. 1 (fresh) as unity, thus:—

Class.	Sensation.	Value.
No. 1.	Fresh.................	1·00
2.	Rather close	2·13
3.	Close.................	3·46
4.	Extremely close	4·66

Taking each observation and dividing the CO_2 found by the mean quantity of No. 1, viz: 0·1943, we get a number which will give the *theoretical* value of its effect upon the senses; and by comparing this with the *actual* value of the *recorded* sensation, we can note whether the difference is *plus* or *minus*, if any. All observed quantities of CO_2 below 0·1943 are considered equal to that number, and all quantities above 0·9054 as equal to it, as the sense of smell does not seem capable of differentiating quantities except between those limits.

Out of 458 fully recorded cases, 186 gave a recorded sensation *in excess* of the theoretical value—that is, the air seemed less pure than would have been expected from its CO_2. In these the average temperature and humidity were both above Class 1.

152 cases gave a recorded sensation *below* the theoretical value—that is, the air seemed purer than would have been expected from its CO_2. In those cases the average temperature was above, but the average humidity below the mean of Class 1.

120 cases gave a recorded sensation that exactly corresponded with the theoretical value. In those cases the average temperature was above, and the average humidity below the mean of Class 1.

Arranging these results and putting F for the temperature in degrees of Fahrenheit, and H for the humidity per cent, we have:—

$$+\,58^\circ{\cdot}6\,F + 86\,H = +\,197.70 \quad [1] \quad \left\{ \begin{array}{l}\text{Aggregate difference of the}\\ \text{recorded and the theoretical value of sensation.}\end{array}\right.$$

$$+\,230{\cdot}8\,F - 82\,H = -\,117{\cdot}37 \quad [2] \qquad \text{Do.}$$

$$+\,244{\cdot}0\,F - 91\,H = \quad 0 \quad [3] \qquad \text{Do.}$$

Adding the two last equations, we have,

$$+\,474^\circ{\cdot}8\,F - 173\,H = -\,117{\cdot}37 \quad [4] \qquad \text{Do.}$$

From [1] and [4] we can determine the respective values of F and H, which are as follows:

$$F = 0{\cdot}4730 \qquad H = 1{\cdot}9765$$

Or, stated in terms of CO_2, by multiplying by 0·1943,

$$F = 0{\cdot}0919 \qquad H = 0{\cdot}3833 \text{ per 1000 vols.}$$

Taking F as unity, we have,

$$F : H :: 1{\cdot}000 : 4{\cdot}1789$$

Or an increase of 1 per cent of humidity has as much influence on the condition of an air-space (as judged of by the sense of smell) as a rise of 4°·18 of temperature in Fahrenheit's scale, equal to 2°·32 Centigrade, or 1°·86 Reaumur.

This may be taken as a proof of the powerful influence exercised by a *damp* atmosphere, corroborating the conclusions arrived at by ordinary experience; and it follows that as much care ought to be taken to ensure proper hygrometric conditions as to maintain a sufficiently high temperature. This is especially the case in the wards or chambers of the sick, in which regular observations with the wet and dry-bulb thermometers ought to be made; these would probably give a valuable indication of the condition of the ventilation, either along with or in the absence of other more detailed investigations. Thus a room at the temperature of 60° F. and with 88 per cent of humidity contains 5·1 grains of vapor per cubic foot: suppose the external air to be at 50° F. with the same humidity, 88 per cent; this would give 3·6 grains of vapor per cubic foot; to reduce the humidity in the room to 73 per cent, or 4·2 grains per cubic foot, we must add the following amount of external air,

$$\frac{5{\cdot}1 - 4{\cdot}2}{4{\cdot}2 - 3{\cdot}6} = 1{\cdot}5,$$

or once and a half the volume of air in the room. If the inmates have each 1000 cubic feet of space, it follows that either their supply of fresh air is short by 1500 cubic feet per head per hour, or else that there are sources of excessive humidity within the air-space which demand immediate removal.—*Proceedings Royal Society*, London, May 4, 1876.

4. *Ninth Annual Report of the Trustees of the Peabody Museum of American Archæology and Ethnology.* 54 pp. 8vo.—The report of the Curator, Mr. F. W. PUTNAM, contains an account of the various recent additions to the Museum, the largest of which is the collection from Peru and Bolivia, made by Mr. Alexander Agassiz and Mr. S. W. Garman, during their journey in South America. This collection, obtained at a large expense, was the gift, even to the cost of transportation, of Mr. Agassiz. It includes several mummies, pottery, idols, cloth and articles of clothing, balls of thread, spindles, and other articles connected with weaving, "which art was developed to a very high state by the ancient Peruvians;" also work boxes, ornaments and beads of silver, copper, shell, and stone, fishing nets, and many other articles; all taken from an ancient burial-place at Ancon. The adjoining burial-place at Chancay, afforded Mr. Agassiz about 70 jars, vases, and other vessels, with terra cotta idols and images." The two illustrate well the ceramic art of the ancient people from the central portion of the Peruvian coast. Besides these, the collections contain numerous articles from Pasagua. One of the five crania from Pasagua had been distorted by circular pressure, giving it the pyramidal form of some crania from near Lake Titicaca, while three others were of natural form and

not at all like the broad depressed skulls of Ancon. A large collection of hair was obtained from Pasagua, showing "not only the peculiar modes of braiding, but also the fact that hair other than that belonging naturally to the head was worn to a great extent in the form of 'switches,' and that even these ancient people were familiar with the use of the 'rats' of the modern hair-dressers." Among the other objects from the same place were a hair-comb, a head-dress of feathers, a sinker attached to a fishing-line, large dishes, a cup of basket work, articles of clothing, fishing nets, pottery. Pacasmayo afforded Mr. Agassiz jars and vases of black clay highly ornamented, many having the human form or that of monkeys and other animals moulded over them; and Titicaca, a series of graceful jars, reminding of Etruscan art, and various objects quite different from those of other parts of Peru. The collections also contain numerous articles illustrating the manner of life, etc., of the modern Indians.

The Museum has also received large collections from the Smithsonian Institution from explorations in California, including 100 human crania, stone mortars and pots, a cup of serpentine, etc.

The Geographical Distribution of Animals, by A. R. Wallace. 2 vols. 8vo, with colored maps and many illustrations. 1876. London. (Macmillan & Co.)

Carte Géologique du Bassin Houiller de Liège, par M. Julien de Macar. 1876. Liège. (E. Decq.)

Proceedings of the American Association for the Advancement of Science, 24th Meeting, held at Detroit, Michigan, August, 1875. Salem, 1876.

Contributions from the Laboratory of the State University. On the various methods of separating and determining Baryum, Strontium and Calcium. Part I: Determination of Baryum. By P. Schweitzer, Ph.D., Prof. Analytical and Applied Chemistry. From the Catalogue of the University of the State of Missouri. 36 pp. 8vo. Jefferson City, Missouri, 1876.

Geschichte der Sulfoverbindungen mit besonderer Berücksichtigung der Sulfosäuren der methylirten und äthylirten Aniline. By George Adams Smyth, of Maine. Doctorate Inaugural Dissertation at the Friedrich Wilhelms-Universität, Berlin. 43 pp. 8vo. Berlin, 1876.

Science Primers, edited by Professors Huxley, Roscoe, and Balfour Stewart. VIII. Botany, by J. D. Hooker, C.B., F.R.S. 118 pp. 18mo, with illustrations. 1876. (New York, D. Appleton & Co.)

OBITUARY.

Professor McCheeney, of Missouri, who accompanied the geological party under Professor Shaler to the Cumberland Gap, was killed while in the excavation he had just made in an Indian mound. It seems that the people of the vicinity crowded around the edges, which gave way, and quite a number were precipitated in the hole. When the excavation was cleared out again, it was found that Professor McCheeney was stooping when the accident occurred, the result being that his neck was broken. He died almost immediately.—*Letter of Prof. Shaler, dated Camp Harvard, Cumberland Camp, July* 10.

Edward Newman, F.Z.S., editor of the Zoologist and Entomologist, recently died in London, at the age of seventy-five years.

Ehrenberg, the eminent microscopic investigator of Berlin, died on the twenty-seventh of last June.

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[THIRD SERIES.]

ART. XXX.—*On Cephalization;* by JAMES D. DANA. Part V. *Cephalization a fundamental principle in the Development of the System of Animal Life.*

THE principle of cephalization has been explained at length in memoirs in former volumes of this Journal,* and to them I would refer for detailed illustrations of the subject. Among these illustrations the attention of the reader is especially called to those from the department of Crustacea, the study of which—occupying more than half of my time between the years 1837 and 1855—brought before me the facts on which it rests. It cannot fail to be perceived, in the review, that, with elevation in grade among the Decapods, for example—passing upward along the line of Macrural forms to the Brachyural (or from the lowest of shrimp-like species to crabs)—there is in general, with the rising grade, an abbreviation relatively of the abdomen, an abbreviation also of the cephalothorax and of the antennæ and other cephalic organs, and a compacting of the structure before and behind; a change in the abdomen from

* For former papers on Cephalization, see this Journal, II, xxii, 14, 1856; xxxv, 65, xxxvi, 1, 159, 321, 440, 1863; xxxvii, 10, 157, 1864; xli, 163, 1866.

One point made in these papers, I would withdraw, viz: that the transfer of the anterior pair of members in Man from the locomotive to the cephalic series is analogous to the transfer which takes place in Crustaceans in passing from the Tetradecapod to the Decapod type, or from the Arachnoid to the Insect type. The latter is plainly a structural transfer, the two anterior pairs of limbs in the Crustacean, or the one in the Insectean class, becoming, by the transfer, strictly cephalic organs (pertaining to the mouth series), and existing thus in a large tribe of species. But in man it is properly only a functional transfer, analogous to cases among spiders and Tetradecapods, where the anterior legs become adapted to serve functionally the mouth or head, without that structural transfer which would place them of itself in the higher order.

an organ of great size and power and chief reliance in locomotion, to one of diminutive size, and no locomotive power; and a change as to the particular pair of legs which is the strongest, from one of the more posterior to the anterior in the series; in other words, that, as grade rises, there is abbreviation behind and before, and thus a concentration of the structure, and a more forward or anterior position in the stronger of the organs of locomotion and prehension. The shrimp and crab are so widely unlike in form that the common eye hardly suspects that they are made up of the same parts or organs arranged in precisely the same order; that the latter is only a shrimp contracted in length, dwindled to almost nothing in its abdomen, and compacted in its mouth organs so that the outer pair makes a well fitting operculum over the others, and shortened in its very long multiarticulate antennæ to a few articulations giving them a length often not a tenth of that of the cephalothorax.

I would refer also to the case among mammals, for an illustration of the same principle—that the lowest forms are those having their locomotive functions located in the posterior parts of the body;* and that in the higher, the forces, or force-organs, are more and more forward in the structure. For example, in the whale—the tail is the propelling organ and is of enormous power and magnitude, and the brain is very small and is situated far from the head extremity in a great mass of flesh and bone furnished with poor organs of sense; a grade up, in the horse or ox, the tail or posterior extremity is no longer an organ of locomotion, and is little more than a caudal whip-lash, and locomotion is performed by organs situated more anteriorly, the legs, and a well-formed head carries a brain which is a vastly higher organ of intelligence than that of the whale—but the legs are simply organs of locomotion, and the hinder are the more powerful; and higher up, in the tiger or cat, the fore-legs—not the hind-legs—are the organs of chief muscular force, and these have higher functions than that of simple locomotion, and, further, the body is proportionally shortened, and the head is shortened anteriorly or in the jaws and approximates thus toward the condition in man. The existence or not

* The fact that fishes have, with few exceptions, the tail as the chief or only locomotive organ, corresponds with their inferior position among Vertebrates. At the same time, it makes the application of the principle of cephalization in determining grade among them quite difficult. In most classes or groups the force-organs constitute a series along the body, and the position of the strongest, and the transfer forward with the rise in grade, is openly manifested. But in nearly all fishes, the tail remains the locomotive organ, with no transfer of its locomotive function to more anterior members, and, therefore, other less obvious and much less certain modes of determining any forward transfer of force are all that remain. And, further, as the conclusions we may arrive at hold good, among all classes of animals, only in case *other conditions in the structure are essentially equal*, the inferences from such evidence can ordinarily extend only to the grade in the family or smaller group to which the species belong.

of a switch-like tail, as in ordinary quadrupeds, has little bearing on the question of degree of cephalization, since the organ is not an organ of locomotion, or one indicating a large posterior development of muscular force. But, approaching man in the system of life, even this seems to have significance.

In accordance with the principle and method illustrated, animals of a given type differ widely as to the conditions and arrangements for action—muscular, sensorial and psychical—in the animal structure. In the low,* there is, usually, large size and strength behind, an elongation of the whole structure, and a low degree of compactness in the parts before and behind; in the high, there is a relatively shorter and more compacted structure, a more forward distribution of the muscular forces or arrangements, and a better head; and the progress in grade, under a type, is progress along lines from the former condition toward the latter, that is, progress in the strength, perfection and dominance of the anterior or cephalic extremity; in a word, it is progress in cephalization.

The principle of cephalization is thus fundamental because, first, the chief center of nervous power or energy in an animal is at the cephalic extremity; and, secondly, because form in nature's species is, with some limitations, an expression of force.*

Again, I have exemplified, in my memoirs, the corresponding fact that progress in cephalization generally attends progress in embryonic development; referring, for illustration, to the loss of the locomotive tail in the frog and many other Amphibians at the time of the passage to the adult stage, and the concurrent development anteriorly of limbs, with the perfecting of the head in structure and senses; to a similar abbreviation posteriorly in the development of modern gars; to the fact that the higher insects rise from a state that is worm-like in form, having no distinction of thorax and abdomen and sometimes furnished with abdominal locomotive appendages, to an adult stage in which the abdomen is greatly dwindled in size, the thorax and abdomen are distinct segments and the former alone has locomotive members and these of perfected structure, and the well-defined head has highly developed sense-organs and exalted senses; and to other examples, all illustrating the view that through the developments going forward in the progress of embryonic development, there may in general be distinguished a cephalization, or forward improvement, of the structure.

It has also been illustrated that the geological progress in the life of the world has been progress in accordance with the principle of cephalization, this being manifested in the succession of forms under the various types, and also in the correspondence

*** For a consideration of the inferior species of some groups, related to half-developed embryonic forms in structure, I would refer to my former papers.**

so often exhibited in a general way—as announced by Agassiz—between the biological succession and embryonic development. I need not dwell on the facts in this place, as they are well understood.

Professor Marsh has recently brought forward facts which exemplify fully the view that the succession in the animal life of the globe has been more or less connected with brain-progress, facts which sustain strongly the doctrine, which I have elsewhere urged, that this progress involved changes in structures in obedience to the principle of cephalization.*

Professor Marsh states† that in the Eocene Dinoceras, from the Rocky Mountain region, the brain was not more than one-eighth the bulk of that of the modern Rhinoceros—its nearest recent ally; in the Miocene Brontotherium it was much larger, about equalling that of the Indian Rhinoceros; and in a Pliocene Mastodon, the brain was larger than in Brontotherium, but not equal to that of living Proboscidians. In a paper on the Eocene Coryphodon of the same region,‡ the brain was even lower than in Dinoceras. Again, after a further study of the subject,§ and a comparison of an extensive series of ancient and modern crania, he gives as his conclusions—in advance of a full and illustrated memoir on the subject: "*First*, all Tertiary Mammals had small brains; *second*, there was a gradual increase in the size of the brain during the age; *third*, this increase was mainly confined to the cerebral hemispheres, or higher portions of the brain; *fourth*, in some groups the convolutions of the brain have become more complicated; *fifth*, in some, the cerebellum and olfactory lobes have even diminished in size;" and, further, "there is some evidence that the same general law of brain-growth holds good for birds and reptiles from the Cretaceous to the present time."

A growth of eight fold in bulk since the early Tertiary is enormous, vastly exceeding in amount the growth in other organs; in fact, the species related to the Rhinoceros have not increased in bulk with the progress of time, but diminished. And the same is true of other species; there is in general higher grade *with smaller bulk*. Moreover, concurrently with the change in the brain, there has been in succeeding species a relative shortening of the head and especially of the jaws, besides other modifications, such as mark a rising grade of cephalization.¶

* Author's Manual of Geology, 1874, p. 596.

† This Journal, III, viii, 66, 1874, and xi, 163, with figures of the Dinoceras brain; xi, 335, with figures of the brain in Brontotherium; and xi, 425, with figures of the brain in the Eocene Coryphodon.

‡ Ibid., xi, 425, 1876. § Ibid., xii, 61, July, 1876.

¶ The jaws are in some mammals relatively short through the incisor portion being imperfectly developed, and this condition is a mark of inferior grade. The shortening referred to above is not of this degradational kind, but that presented in a diminished distance between the normal incisor-extremity and the normal position of the posterior molar—an abbreviation which reaches its extreme limit in man.

But have other peculiarities of the later species any connection with this growth and change of brain? We can hardly doubt, that, inasmuch as there has been no corresponding change in the animal's bulk, there must have been concordant changes somewhere, and change of equal magnitude and importance; and the supposition that they included the structural modifications which mark the line of species from the early Tertiary onward, does not appear to be extravagant.

Such growth or progress in the brain and nervous system—the seat of power in the animal—is accordant with, and consequent upon, the great fact that this is the part of the structure which comes into actual contact with outside and inside nature. It is the means in an animal by which communication is had with the outer world and also with its own inner workings and appetites; that which takes impressions, which feels whatever inspires energy, prompts to action, exhilarates, or exalts; the part, therefore, which must grow whenever circumstances favor progress, and, at the same time, fail to grow or dwindle under unfavorable circumstances: which communicates whatever it receives to the being to which it belongs, and, in each case, to the part or parts responding to its condition; which reaches every part of the system and dominates in all action and growth, and hence must cause an expression of its own condition in some way on the structure; which, moreover, must ordinarily produce correlate changes in correlated parts, if any, because in its own nature and distribution the system of correlation has a full expression. Energetic use gives increasing strength to muscle; and that wonderful strengthening growth in the brain since Eocene times may also have come from use.

It would hence appear that a prominent means of change in species is the action of influences on the brain; that the brain grows and changes and sends its changing forces through the animal; and that this gives progress, or degradation: and hence it is that progress is exhibited in cephalization, and degradation in decephalization. The brain could not grow to the adult stage in the frog without the change in the structure that cotemporaneously takes place; and no more could the brain of a species like a shrimp grow into a brain of the higher grade of a crab without its determining in some sense a concordant higher grade of structure in the animal, involving the loss of locomotion in the abdomen and also other changes.

We recognize, as evidence of upward progress in Man, an increasing height, width and erectness of the forehead, and a shortening of his jaws, and see therein evidence of improved intellect; which means higher grade of cephalization. But, more than this, the erect form of Man, the shortened arms, the naked skin, as well as the large, smooth-surfaced cranium, may

also be as directly and necessarily connected with, and dependant upon, his superior degree of cephalization in the system of animal life; while the hairy skin, the long arms, the crested skull, the inclined posture of the man-ape, may be all involved in the ape's inferior degree of cephalization. If so, the development of the brain in Man and of all the highest structural perfections of the Vertebrate type which he exhibits is inconsistent with the existense of the hairy covering and some other circumferential as well as interior characteristics of the brute.

We may therefore believe that in all progress in grade, upward or downward, there was involved some changes in thé animal structure of the kind expressing degree of cephalization. Brain-progress could not have taken place without structural progress: and with the brain eminently the growing organ, the brain-progress would have had a determining relation to the latter. More than this, many peculiarities of form or structure in animals which are not evidently marks of grade in cephalization, or have little or nothing to do with it, may have had the same source. The type of structure characteristic of a group of species is beyond doubt connected with some peculiarity of chemical composition, or rather of chemical compounds present, in the great center of activity; and this chemical condition once established, the progress afterward, connected with brain growth or change, might well be a development in that line of type structure, displaying the type under new forms.

I do not mean to imply, in the above, that the method of progress pointed out accounts for the existence of the various types of structure in the animal kingdom, or for all the developments under them; but only that, whatever the types of structure in course of development, there was also a general subordination in the changes to the principle of cephalization; because the nervous system by its growth and domination must necessarily have determined such subordination; and, further, that, through the same agency, the development of other peculiarities of structure and form, not obviously marks of grade, may have been occasioned. The origin of the grander types of structure must be connected with the profoundest of molecular laws; and how connected, man may never know.

These views may hold whatever be the true method of evolution. The method by repeated creations through communications of Divine power to nature should be subordinated, as much as any other, to molecular law and all laws of growth; for molecular law is the profoundest expression of the Divine will, the very essence of nature; and no department of nature is without its appointed law of development. But the present state of science favors the view of "progress through the derivation of species from species, with few occasions for Divine

intervention."* If then there has been derivation of species from species, we may believe that all actual struggles and rivalries among animals, leading to a "survival of the fittest," must tend, as in Man, to progress in cephalization, and dependent structural changes. In fact, mere living, the surmounting of the daily obstacles in getting food and shelter and satisfying ordinary desires, may have given growth to the brains and structures of the Eocene mammals, aiding, but perhaps exceeding, all other influences from environments.

The source of variation here pointed out is not at all at variance with Darwinism. Darwin, in fact, does not aim to explain the origin of variation among species, but chiefly the workings of natural selection—variations being in progress by some means—in leading to the "survival of the fittest" of the varieties. Variation he refers to environments, and especially to action on the genital system. The genital system may have this prominence in plants; but for animals I would give the *nervous* system the higher place, inasmuch as upon it environments make their first and most powerful impress.

One reason why plants present but few simple types of structure compared with animals, and why marine plants are almost the same for all geological time, and thus strongly contrast with the immense diversity and complexity of types and kinds among marine animals, may be found in the fact that plants possess not that feeling, knowing, outreaching and inworking thing, a nervous system. This, however, is not all: for the presence of so large a proportion of nitrogen in the animal structure, in addition to other elements, gives an opportunity for a vastly wider range of chemical combinations.

ART. XXXI.—*On an Electro-magnetic Machine constructed at the Cornell University Workshop*; by WM. A. ANTHONY, Professor of Physics at the Cornell University.

THIS machine is essentially the same as the "Gramme" electro-magnetic machine, and its construction was undertaken on account of the difficulty that seemed to exist in the way of procuring the "Gramme" machine from the European manufacturers.

The soft iron core of the revolving armature consists of a coil 24 cm. external diameter, 20 cm. internal diameter, and 15 cm.

* This sentence is cited from my Manual of Geology, 1874, p. 603. After it come these words:—"For the development of Man, gifted with high reason and will, and thus made a power above Nature, there was required, as Wallace has urged, the special act of a Being above Nature, whose supreme will is not only the source of natural law, but the working force of Nature herself," and this I still hold.

wide, of very soft iron wire 3 mm. *square.* To prevent, as far as possible, the formation of induced currents in the coil itself, which would consume power to no purpose, the wire, while being wound into the coil, was drawn through a thick shellac varnish, which, it was thought, would to a certain extent insulate the adjacent wires from each other.

The conducting wire of the armature consists of 100 coils, each of 4 meters, of cotton-covered copper wire 2 mm. square. These coils terminate alternately on the right and left of the armature, and each set is connected with fifty copper strips which surround the axis and serve to transmit the current in the usual way. The two sets of coils are entirely independent of each other, and constitute practically two distinct armatures. The resistance of each armature as employed in the machine is very nearly $\frac{1}{4}$ of an ohm.

The cores of the two inducing magnets are 7·5 cm. diameter, 60 cm. long. At the middle of each is a block of cast iron which serves as the magnetic pole, 15 cm. wide, and embracing about one-third of the circumference of the armature. On each end of the cores is a bobbin 25 cm. long and 15 cm. diameter, wound with eight layers of copper wire 3·5 mm. square. The eight layers are not joined on the bobbins, but form so many independent conductors, the terminals of which are carried to a commutator on the base of the machine. The commutator serves to combine the wires into one continuous conductor having a resistance a little less than one ohm, or into 4, 8 or 32 conductors in multiple arc.

The wires from the four brushes which collect the currents from the armatures are carried to another commutator, which serves to join the two armatures in series or in multiple arc with the coils of the inducing magnet in the main circuit, or to put one armature in circuit with the magnet coils, while the other communicates with the terminals of the machine and furnishes the useful current.

Preparations were commenced for making a complete series of tests of the working of the machine, but it had been decided to send the machine to the Centennial exhibition, and, as the preparations could not be completed in time, only a few tests were made. Large German-silver wires were stretched across the room to serve as resistance, as described by Professor Pickering in his account of the tests of the Farmer machine at the Institute of Technology in Boston. For measuring the currents, a tangent galvanometer was especially constructed, and its constants determined from a large number of experiments with the copper voltameter.

The tables below give some of the results of the experiments. The observations and computations were made under my direction, principally by Mr. M. M. Garver, now a graduate of this

University in the department of Chemistry and Physics. More extended tests will be made after the machine returns from the exhibition, when a dynamometer will be procured to measure the power consumed.

TABLE I.

Armatures joined in series; resistance ½ ohm.
Magnetic coils joined in series; resistance 1 ohm (nearly).

No. of revolutions per minute.	E. M. F. Volts.	Total resistance. Ohms.	Current. Webers.
543	68·9	6·74	10·22
572	54·05	11·06	4·91
560	5·17	141·5	·0364
419	36·85	11·06	3·35

TABLE II.

One armature supplying the useful current, the other in circuit with magnet coils which were joined in series.

No. of revolutions per minute.	E. M. F. Volts.	Total resistance of useful circuit. Ohms.	Useful current. Webers.
323	24·1	4·39	5·49
319	23·8	3·67	6·50
313	23·34	2·82	8·27
309	23·28	2·65	8·78
309	23·17	9·81	2·36
309	25·1	19·19	1·31
309	25·8	62·95	·40
279	18·7	62·95	·30
279	16·6	2·82	5·88

Only one experiment with the armatures in multiple arc was performed, and in this, a water voltameter, having platinum plates 6 x 8 cm. enclosed in separate tubes to deliver the two gases separately, was included in the circuit. The magnet coils were joined to give four circuits in multiple arc, having a resistance altogether of $\frac{1}{16}$ ohm. The resistance of the armatures in multiple arc is ⅛ ohm. Hydrogen gas was delivered at the rate of 257 c.c. per minute, which corresponds to a current of about 43 Webers. The speed in this experiment was not recorded, but could not have been far from 320 revolutions per minute. I speak of the experiment only to show the range of adaptability of the machine.

A series of experiments was made to determine the character of the light produced by the machine, with the following general result:

Number of revolutions per minute,	487 to 525.
Current by galvanometer,	10·5 to 11·5 Webers.
Resistance of light, about	4 ohms.
Entire resistance,	5·65 ohms.
Intensity of light (average),	1600 candles.

The intensity of the light was determined by first comparing it with that of a coal-oil lamp and then comparing the latter with a standard candle.

In all these experiments the machine was driven by a five horse power oil engine, known as "Brayton's Ready Motor," built by the "New York and New Jersey Ready Motor Company." An interesting fact appeared upon comparing the oil used by the engine with that consumed by the lamp used for comparison with the electric light. The lamp had a flat wick one inch wide. This was carefully trimmed and the light carefully adjusted before the experiments. The experiments continued four and a half hours, during which time the lamp burned continuously. The lamp consumed per hour 29·8 grms. of oil. The electric light was equivalent to 234 lamps, that is, equivalent to the light produced by the combustion of 6973 grms. of oil per hour. The engine consumed three kilograms of a light gravity crude petroleum per hour.

It would seem, therefore, that the combustion of the oil in the engine produces, after the transformation of the energy evolved, first into mechanical power, then into the electric current, and lastly into light, nearly three times as much light as when consumed in the ordinary lamps.

I would add that, while the machine produces a very efficient light, which I have used with great satisfaction in my lectures, it is not so well adapted as it might be to this particular purpose. The electro-motive force developed is too small, and the internal resistance of the machine too small, for the best effect with the light. The small resistance of the machine makes the regulation of the light difficult. (The regulator used was the Foucault.) For, the light being about two-thirds the resistance of the circuit, any change in the relative position of the carbons, changes materially the entire resistance, and this, since the coils of the inducing magnet are in the main circuit, makes a very great difference with the current.

To make a more perfect machine for the production of the light and retain the advantages it now possesses for other purposes, it is proposed to construct a new armature, using finer wire and a greater number of coils, and connect the terminals of these with a commutator that will permit them to be joined in series as usual, or in multiple arc in groups of two or three, these groups being joined in series as though they were single coils. Such an arrangement will produce a machine which can be readily adapted to the various conditions of external resistance met with in electrical experiments.

Physical Department, Cornell University, Ithaca, N. Y., July 24, 1876.

ART. XXXII.—*On the Sea-bottom Deposits observed during the Cruise of the Challenger in a report to Prof. Wyville Thomson;* by JOHN MURRAY, Esq., naturalist of the expedition.*

THE kinds of deposits obtained in soundings by the Challenger, may for the present be classed under the following heads:—

1. *Shore-deposits.*
   (*a*) Blue and green muds.—Met with near the shores of most of the great continents and islands.
   (*b*) Gray muds and sands.—Met with chiefly near oceanic islands of volcanic origin.
   (*c*) Red mud.—Met with on the eastern coast of South America.
   (*d*) Coral-mud.—Met with near coral reefs.
2. *Globigerina-ooze.*—An abundant oceanic deposit not met with south of latitude 50° S.
3. *Radiolarian ooze.*—An oceanic deposit met with only in the Western and Middle Pacific.
4. *Diatomaceous ooze.*—An oceanic deposit met with only south of 50° S. latitude.
5. *Red and Gray Clays.*—The most abundant oceanic deposit.

The above names have been selected as indicating those elements which give the predominating character of the deposit. As a rule, when the débris of continents or islands, the dead shells of Foraminifera, the exuviæ of Radiolarians, etc., the frustules of Diatoms, or red or gray clayey matter—when any of these have appeared to make up considerably more than one half of the specimen under examination, it has been called a shore-deposit, a Globigerina, Radiolarian, or Diatom ooze, or red or gray clay.

Sometimes it has been doubtful whether a specimen should be placed under one of the above heads or another, on account of the nearly equal ratio of constituents, or where one deposit overlies another of a different kind. In these cases the specimen has been placed under that head with which, on a general view, it has seemed to have most in common, or to which the surface-layer belonged, and a detailed description has been added in the list.

A sixth kind of deposit or formation might have been added, to embrace those bottoms in which a great quantity of the *peroxide of manganese* occurs. This substance, in the form of

* From the Proceedings of the Royal Society, vol. xxiv, No. 170. The general remarks here cited are preceded in the Report by detailed descriptions of each of the soundings in the course of the expedition. These notes and conclusions are from a preliminary report, which is soon to be followed, now that the expedition has returned, with a fuller statement.—EDS.

nodules or concretions, of incrustations or in grains, has been found in nearly all sea-deposits and at all depths in more or less abundance. However, for the present it has been considered best to treat of its occurrence separately, at the same time pointing out those regions where we have found it in greatest abundance.

A few remarks may now be made upon each of the kinds of deposits indicated.

1. *Shore-deposits.*—It has been found that the deposits taking place near continents and islands have received their chief characteristic from the presence of the débris of adjacent lands. In some cases these deposits extend more than 150 miles from the coast. Several varieties can be recognized among these shore-deposits.

(*a*) *Blue and Green Muds.*—In the great majority of cases the deposits near continents and large islands, containing the older and crystalline rocks, have been of a blue or green color; the only exception appears to be the east coast of South America, where we have a red mud, to be presently referred to.

In from 100 to 700 fathoms these deposits are often of a green color, due to the presence of a green amorphous clayey matter, and dark and pale green glauconite particles. Beyond 700 fathoms they are usually of a blue or dark slate-color, having a thin upper layer of a red or brown. This red layer is a soft ooze, whilst the blue mud or clay beneath is very compact and tenacious. Much amorphous clayey matter and fine particles of mica, quartz, and other minerals are found in all these deposits, the mineral particles increasing in size as we approach the land.

Down to 1500 fathoms, we have generally found that Pteropod, larval Gasteropod, and Lamellibranch shells were tolerably abundant, and that there were many of the shore forms of Foraminifera, as Textularias, Rotularias, Nodosarias, Uvigerinas, Lagenas, etc. Pelagic Foraminifera occur throughout the deposit, but not in such abundance as in a true ocean-deposit. The frustules of Diatoms and their broken parts are numerous. Manganese grains are found in many of the bottoms, usually in the deeper soundings. We have also found imbedded in these muds pieces of wood, fruits, portions of fruits, and leaves of trees. Large pieces of rock, as pumice and granite, and rounded pebbles also occur. Our soundings near the southern ice-barrier were muds of a blue color, containing many granitic and other pebbles and blocks, mostly rounded, and many Diatoms, and resembled in most respects the deposits we found off the east coast of North America, Halifax to New York.

Beyond 1500 or 1700 fathoms, Pteropod and Heteropod shells are usually not found, and in 3000 fathoms hardly a Foraminiferous or other carbonate-of-lime organism remains.

Siliceous organisms occur at all depths, but at times their remains would seem to be completely removed.

These green and blue muds have been found to prevail in all the enclosed seas we have visited, as Arafura, Banda, Celebes, and China seas, Inland Sea of Japan; and in all these the carbonate-of-lime organisms would appear to be removed from the bottoms in depths less by some 400 or 500 fathoms than on open coasts.

In the green muds from 50 to 700 fathoms we have found those beautiful casts of Foraminifera, Pteropods, *Echini*-spines, and other carbonate-of-lime organisms, frequently in great numbers. These are of a dark green, pale green, and dirty white color. In all cases where these green internal casts occur we have many glauconite grains in the bottom. Beyond 700 fathoms these casts seldom occur, and when they do they are very sparingly distributed; and the same may be said of the glauconite grains which accompany them. River-muds, in which Pteropods, Radiolaria, and pelagic Foraminifera are usually wanting, are included in these deposits.

The following are the localities in which we have found the blue muds (an asterisk before the locality indicates that glauconite casts and grains have been found there):

* Off coast of Portugal; off Virgin Islands (?); * off coast of North America, Halifax to New York; off Guinea, coast of Africa; * off Cape of Good Hope; off Antarctic ice-barrier; * off Australia; * off New Zealand; * off New Guinea and Phillipines, and throughout the seas of the East-Indian archipelago; * off Japan; off east coast of South America.

The following are the depths of the soundings which have been placed under this head:—

Blue Muds.

fms.	fms.	fms.	fms.	fms.	fms.	fms.
1125	600	2020	1300	40	2100	2000
1290	3875	1750	2200	32	700	1075
1475	2425	2500	400	1100	90	2250
1380	1700	2325	150	700	150	20
1800	1240	1250	140	2800	375	2675
1000	1350	1675	75	1425	2225	1875
525	1340	1800	39	2550	2050	2225
900	1250					

Green Muds.

fms.	fms.	fms.	fms.	fms.	fms.	fms.
470	100	120	400	580	705	245
560	150	650	10	129	185	565
80	2200	950	70	255	37	775
75	290	1200	800	100	152	

(*b*) *Gray Muds and Sands.*—Near volcanic islands we have found that the deposits have a distinctive character, from the presence of the débris of volcanic rocks. The presence of pieces of pumice, scoria, etc., prevents this deposit having that clayey character so characteristic of the blue mud. The color is generally gray, but occasionally is a black sand or a more or less slate-colored mud. In some places the shells of oceanic organisms make up a large part of these muds.

Down to about fifteen hundred fathoms we have Pteropod, Heteropod, and surface Gasteropod shells, and the shore forms of Foraminifera are common. Deeper than 1500 fathoms, Pteropod shells are rare or entirely removed. Pelagic Foraminifera are found at all depths; but occasionally they and the siliceous organisms are quite absent at a depth of little over 2000 fathoms, and then we have a clay or mud with many small particles of pumice, scoria, etc. Manganese appears to be intimately associated with some of these bottoms, especially where the débris of augitic lavas are present, as at Sandwich Islands, Canaries, and elsewhere. Off the Desertas, in 670 fathoms, all the dead shells, pieces of Polyzoa, etc. had a slight coating of this substance, and we have had indications of the same thing in even less depths. In 1100 fathoms off the Canaries some pieces of shell had rather a thick coating; and in 1575 fathoms, not far from this place, the dredge brought up a great quantity of a Gorgonoid axis deeply imbedded in or coated with this black oxide of manganese.

In some localities this deposit extends to a great distance from the islands, as at Hawaii, 200 miles or more.

The following are the depths of the soundings which we have classed as

Gray Mud.

fms.	fms.	fms.	fms.	fms.	fms.	fms.
670	7	1000	260	20 to 100	2150	2650
1150	640	1125	360	75	2600	1525
930	1750	1070	1100	520	1050	420
1500	620	1000	50	630	500	590
278	1890	1675 (?)	150	600	2050	620
630	1525	465	600	1200	2875	680
560	450	675				

Occasionally a few casts of the Foraminifera have been observed of a red color. These were usually very rough, and had not the delicate hues of the green glauconite casts. One very remarkable exception occurs:—off the Crozets there were (in 600 fathoms) many beautiful casts of the carbonate-of-lime organisms of a pale straw-color. None of the glauconite grains were noticed in the same sounding or locality.

(*c*) *Red Mud.*—It has already been stated that the deposit

along the east coast of South America, from Cape San Roque to Bahia, differed from the deposits found along the shores of other continents and large islands in being of a red color. There can be little doubt but that this red color is due to the presence of the ochreous matter carried into the Atlantic by the South American rivers. There are reasons for thinking that the red color of some of the deep-sea clays in this region of the Atlantic may have a like origin.

The soundings near the shore and in shallow water have a deeper red color and contain larger mineral particles and fewer organic remains than those farther from land and in deeper water. The mineral particles are chiefly quartz and mica.

In all these soundings there are many pelagic and other Foraminifera, Heteropod, Pteropod, larval Gasteropod, and Lamellibranch shells, Coccoliths, and Rhabdoliths. Siliceous organic remains, as of Diatoms and Radiolaria, are almost quite absent in these bottoms. In some of the shallower depths a few red-colored casts of Foraminifera were observed; but these were rare, rough, and more or less imperfect.

The following are the depths of the soundings along this coast:—

fms.	fms.	fms.	fms.	fms.
1375	1650	32	1600	1015
500	675	400	1200	1275
2050	120	1715	700	2150

(*d*) *Coral-Mud.*—This is a deposit found in the neighborhood of coral reefs. It is characterized by a large quantity of amorphous calcareous matter, by the débris of coral reefs, by many large calcareous forms of Foraminifera, and by broken pieces of Polyzoa, etc. All the deposits about Bermuda are of this nature, extending from the edge of the reef down to a depth of 2500 fathoms. At 1000 fathoms the mud assumes a rose tinge; this deepens into a red color with greater depth, and the accompanying decrease of carbonate of lime and increase of clayey matter, until the coral-mud merges into the red and gray clays of the surrounding ocean. About Bermuda very few mineral particles were found. In some of the soundings to the S. W. of the island there were some small pieces of a green rock like those at St. Paul's Rocks, and probably serpentine. One or two pieces of quartz, or sanidin, a piece of mica, and a small piece of pumice (?) were also noticed. Dissolving away carbonate of lime in some of the shallower soundings only a trace of clayey matter remained with a perceptible rose tinge. No casts of the Foraminifera were noticed about Bermuda.

At the Virgin Islands, at Tongatabu, at Fiji Islands, at Cape York, Admiralty Islands, Honolulu, and Tahiti we also met with coral-muds. Except at Cape York, these muds appeared

to exist as a narrow band around the land, and had usually a considerable admixture of clayey matter and mineral particles. Where there was much clayey matter we found usually a few rough red casts of the Foraminifera.

The following is a list of the depths of the soundings included under coral-muds:—

At Bermuda.			At other places.		
fms.	fms.	fms.	fms.	fms.	fms.
2250	2100	1250	460	140	25
1820	1950	1575	390	210	100
950	2650	1500	625	610	40
430	1325	200	18	70	90
1375	1075	37	240	25	100
2450			315	16	
			255		

2. *Globigerina-ooze.*—After the deep-sea clays, this is the most abundant deep-sea deposit. It has occurred at all depths from 250 to 2900 fathoms. The *Globigerinæ*, which give at once the name and chief characteristic to this deposit, are really found all over the bottom of the ocean. Even in our deepest clays, if the surface-layers be selected and all the amorphous matter be washed away, one or two shells of some variety of pelagic Foraminifera can usually be detected. By pursuing this method I have failed only on one or two occasions. They appear to be quite absent in the Arafura Sea. It is, however, when they occur in vast numbers that they form the deposit known by this name; at least such is the sense in which it is here used. We did not find a Globigerina-ooze in any of the enclosed seas, in the Southern Ocean south of lat. 50° S., nor in the North Pacific north of latitude 10° N.

In the Southern Ocean only one small species of *Globigerina* was found in the surface-waters; but in the North Pacific many varieties of pelagic Foraminifera abound near the surface of the ocean. In other parts of the preceding oceans, and in the other oceans we have visited, it occurs in irregular patches, being always present in the open ocean when we have depths of less than 1800 fathoms. Its presence or absence at depths beyond 1800 fathoms is, however, determined by conditions at present unknown. A number of varieties occur both as to color and composition. Some specimens are nearly pure white, others have a rose-color, and others are red or dark brown. The red and brown color arises from the presence of the oxides of iron and manganese. In the white varieties the sediment, after dissolving away the carbonate of lime, is in some specimens abundant, in others not abundant, and is either of a red or slate-blue color. We find the former color to prevail in those soundings

far from continents and large islands, and the sediment is not abundant except where pumice or scoria is present. The latter, or slate-blue color, is found in those soundings more or less near continents and large islands; and it is suspected that this sediment has its source chiefly from the disintegration of these adjacent lands.

Mica, quartz, pumice, scoria, and other mineral products are met with; but in those soundings farthest from land a little piece of pumice or scoria may be the only trace of mineral particles.

In some specimens there are very many remains of organisms with siliceous shells, as Radiolaria, Diatoms and Challengerias; but in others these remains are almost entirely wanting. In three soundings in mid-Atlantic, between the Canary and Virgin Islands, and in several soundings in the South Pacific, manganese in the form of grains and nodular concretions is very abundant. As a rule, however, this substance occurs rather sparingly in Globigerina-ooze. In some instances we get little nodules of these bottoms, the shells as it were being run together by a siliceous cement. Many small pieces of cherty-like mineral also occur, which are angular and soft, and do not look as if they had been transported. Manganese nodules occurring in the Globigerina-ooze have often a nucleus of a yellow and green color, in which Globigerina-shells can be seen; but their carbonate of lime has been entirely removed, and replaced by a silicate. There are reasons for thinking that these indications of flint (?) occur only in those samples where the siliceous shells of Radiolaria, Diatoms, etc., are wanting, and do not occur where these organisms are present. A reëxamination of all the bottoms must be made before this statement can be definitely affirmed. Casts of Foraminifera occur very sparingly in Globigerina-ooze; in the purest samples not at all. In those with an admixture of clayey matter we have frequently one or two partial casts of a very rough character. In two soundings, Nos. 211 and 301, in the Pacific, we found the Foraminifera not only filled, but also coated, with a red substance, so that we had both an internal and an external cast, the two being connected by little rods representing the foramina of the shell. In these soundings there was much clayey matter and disintegrating pumice and scoria.

In a few soundings in the Pacific, as No. 304, we have had a Globigerina-ooze on the surface of the bottom, and a foot beneath a nearly pure red or brown clay. Again, as in Nos. 268 and 307, we have the reverse arrangement, a clay occupying the surface, and the deeper layers having many *Globigerinæ.* In all these cases the surface-layer has been normal with the

other soundings in the same region as to depth. In the first case we might bring in elevation to account for the Globigerina-ooze overlying the red clay, or we might suppose that chemical changes are going on in the deeper layers which remove the carbonate of lime. In the second case we may account for a red clay overlying a deposit with many *Globigerinæ* in it by supposing a depression of the bottom after the latter had been laid down; or we may believe that agencies are now removing carbonate of lime from the surface-layer, and that these were not active in some past time.

This deposit occurs, in one sounding, in the Pacific at a depth of 2925 fathoms in mid-ocean. In the eastern part of the Atlantic it occurs also at great depths.

The following is a list of the depths at which we have found a Globigerina-ooze:—

Atlantic Ocean.

fms.	fms.	fms.	fms.	fms.	fms.
1090	1900	2200	1350	1425	2275
1525	1950	1675	900	1650	2475
2250	2325	1675	2025	2300	2200
2225	1420	1240	2660	2300	2150
1945	2575	1000	2675	2400	2275
1975	2450	2500	2400	2400	2050
1150	2475	2275	1500	2075	1900
2300	2175	1850	1900	780	2025
2025					

Southern Ocean.

fms.	fms.	fms.	fms.	fms.	fms.
1900	1570	1375	1600	1800	2150

Pacific Ocean.

1974	1350	1675	2925	1915	1500
1100	1450	2000	2425	1600	1825
275	1700	1100	1940	2025	1775
400	1400	1850	2075		

3. *Radiolarian Ooze.*—Organisms with the siliceous skeletons abound in the surface-waters, and apparently also in the deepest waters, of all the oceans and seas we have visited.* The skeletons of these organisms are found in all, or almost all, the sea-bottoms. Even in those cases where at first sight they would seem to be quite absent, a more careful examination (by dissolving away a large quantity of carbonate of lime where this exists, and examining the sediment by careful washing in the case of clays, etc.) will usually reveal a Radiolarian skeleton, a Diatom frustule, or broken portions of these.

* They are, however, much more numerous in the Pacific than in the Atlantic, especially in the equatorial waters.

It is, however, only in some limited areas that these exuviæ rise into such prominence as to be characteristic of the deposit taking place. Such is the case in the Antarctic, where we have a Diatom-ooze, and in the Western and Middle Pacific, where we have the above deposit.

Our deepest sounding (4475 fathoms or 4575) was a Radiolarian ooze; with the exception of a little amorphous matter, manganese particles, a few yellow cherty-like particles, and some pumice pieces, this bottom was entirely composed of the exuviæ of organisms with siliceous skeletons—as Radiolaria, one or two Diatoms, and some organisms which seem to be undescribed (Challengerias), but which are numerous in the deeper waters of the Pacific.

A section of about three inches came up. The upper two were of a red color, due to the presence of much manganese; the lower one was of a pale straw-color, and contained relatively few manganese grains.

In our trip from the Sandwich Islands to the Society Islands we again met with Radiolarian ooze. Between 7° and 12° north of the equator we came on a patch represented by four soundings, some of these containing not a single *Globigerina;* then just on the equator, in two soundings, one at a depth of 2925 fathoms, we got a Globigerina-ooze containing a good many Radiolaria. Between 2° and 10° south we again had a patch of Radiolarian ooze represented by three soundings, and containing only a few pelagic Foraminifera or their broken parts. The occurrence of this patch of Globigerina-ooze in the position indicated, and the comparative or total absence of the Globigerina-shells in the deposits a little to the north and south of it, is sufficiently curious and significant. It will be well to note that, in the Globigerina-patch, manganese and other mineral particles are much less abundant than in the adjacent Radiolarian. Note also the presence of the south equatorial current and the dip of some isotherms over the Globigerina-patch. One or two soundings to the east of Japan might have been classed under this head; but in them the siliceous remains do not make up over one third of the sample in bulk. Generally it may be said that in the Western and Middle Pacific the siliceous remains of Radiolaria and Diatoms are abundant in the deposits, whereas in the South Pacific and Atlantic they are much less so, or absent in the bottoms.

The following are the depths of the soundings placed under the head of Radiolarian ooze:—

fms.	fms.	fms.	fms.
{ 4575	2700	2250	2350
{ 4475	2900	2600	2750
2750			

4. *Diatomaceous Ooze.*—South of the latitude of the Crozets, on our southern trip, we found Diatoms abundant, both in the surface waters and in the bottom.

About the Crozets, Kerguelen, M'Donald's Islands, and close to the ice-barrier, the frustules of these organisms were very abundant in the soundings, but were masked by much land-débris. Between the parallels of 53° and 63° S., i. e., between the north edge of the ice and the latitude of M'Donald's Islands, we got in three soundings a pale straw-colored deposit, composed principally of the frustules of Diatoms and their broken-down parts. In addition, they contained a good many Radiolarian remains, a few specimens of one small species of *Globigerina*, a few particles of mica, quartz, and granitic pebbles, also a little amorphous blue clayey matter. No manganese particles were noticed. The one of these soundings which is nearest to the ice contains much amorphous clayey matter and larger mineral particles than the other two. When dried this deposit is of a white color, and is very light.

The depths of the soundings referred to above are 1260, 1975, and 1950 fathoms.

5. *Red and Gray Clays.*—By far the most abundant oceanic deposits are the deep-sea clays. These are of a gray, red, or dark chocolate-color, and are found at depths greater than 2000 fathoms. The red and chocolate-colors of many of these clays are due to the presence of oxide of iron in the first and oxide of manganese in the latter instance. Most of them contain some carbonate of lime in the form of Globigerina shells; in one or two instances, however, I have not been able to find a single shell, nor has acid caused the least bubble of effervescence. The remains of siliceous organisms occur also in great numbers in the clays of some regions—so much so that, as I have stated, some of those soundings in the Northwest Pacific which have been classed as clays might have been called Radiolarian ooze. In most places, however, they are nearly or quite absent. These clays are not amorphous in the true sense of the word—not amorphous in the sense in which a chemical precipitate is amorphous. They all contain small white and other colored mineral particles in great abundance—exceedingly small particles, so as to be recognized only under the high powers of the microscope. They contain amorphous matter, it is true; but it is doubtful if this ever makes up so much as a half of any sample in bulk. They also contain larger mineral particles, as quartz, mica, pumice, scoria, peroxide of manganese, and other mineral particles. Quartz and mica particles appear to be present only in some localities, as the North Atlantic and elsewhere. Peroxide of manganese is perhaps always present in the form of grains or nodules, sparingly distributed in some

regions, in others making up nearly a half of the deposit or formation.

Pumice (the common feldspathic or the highly vesicular augitic variety) and scoria appear to be universally distributed over the bottom of the ocean, and to be abundant in most of the deep-sea clays and present in them all. In those clays farthest from continents and islands, sharks' teeth, ear-bones of whales, other bones of whales, and bones of turtles (?) are very frequently found, all these having usually a more or less thick coating of peroxide of manganese. The following are the depths at which we have found these red and gray clays:—

Atlantic.

fms.	fms.	fms.	fms.	fms.	fms.	fms.
2740	2575	3025	2475	2650	2875	2700
2950	2435	2800	2600	2500	2750	2350
2750	2385	2960	2850	2360	2750	2275
2800	2675	2850	2675	2575	2700	2550
3150	3000	2700	2800	2850	2750	2650
2720	2975	2600	2650			

Southern and Pacific Oceans.

fms.	fms.	fms.	fms.	fms.	fms.	fms.
2600	2275	2500	2900	2740	3000	2250
2600	2550	2425	2775	3125	2900	2335
2600	2650	3900	2050	2025	2610	2270
2900	2450	3600	2530	2850	2350	2400
2650	2325	2900	2900	2950	2325	2600
2325	2300	2300	2300	2875	2385	2550
2450	2475	2575	2350	2775	2450	2300
2440	2450	2800	2900	2225	2375	

6. *The Manganese in Deposits.*—The peroxide of manganese, in the form of minute grains, concretions, nodules, aggregations, or incrustations, occurs widely distributed in ocean-deposits. It has been met with most frequently in the deep-sea clays; indeed it seems to be present in all of them, sparingly in some localities, abundantly in others.

It is, however, not confined to these clays; it has been found in most of the other deposits and at all depths greater than 500 fathoms. In the Globigerina- and Radiolarian-ooze and in the clays it usually assumes the forms of minute grains, pellets and nodules. In those bottoms to which it gives a chocolate color, the higher powers of the microscope show small, round, red-brown grains of manganese, often with a dark spot in the center.

The nodules vary from little pellets to masses of a large size and of several pounds in weight. In some regions everything at the bottom, even the bottom itself, would appear to be overlaid by and impregnated with this substance. In the foregoing list, as at No. 318 and elsewhere, some of the nodules have

been described with a little detail. The varieties which are most commonly procured may be here mentioned:

(*a.*) Nodules of a black-brown color throughout, the manganese being laid down in concentric layers, which are evident from their enclosing lines of red clay.

(*b.*) Nodules having a nucleus of pumice which is surrounded by concentric layers, the original nucleus being often very deeply impregnated by spider-like ramifications of the manganese, or nearly the whole pumice may be replaced by manganese. When pieces of bone have formed the nucleus we have much the same state of things. The compact bone of the tympanics of cetaceans does not, however, appear to alter so rapidly as other bone; and hence it may be that we get ear-bones in such great numbers.

Sharks' teeth of all sizes (one was four inches across the base) are frequent, and are sometimes surrounded by concentric layers of nearly an inch in thickness. A siliceous sponge (*Farrea*) was found imbedded in two inches.

A mass of red clay may occupy the center of the nodule. The nucleus is occasionally a mottled yellow-and-green substance, with agate bands in some parts, and *Globigerina*, the carbonate of lime being replaced by silicate in these last. This nucleus can be cut with a knife, like new cheese, or it is hard and brittle, breaking with a conchoidal fracture.

Large flat aggregations occur which seem to have been formed on hardened flat portions of the bottom.

The Globigerina-shells and Radiolaria are at times covered by small specks of the manganese; and in the former these are deposited in the substance of the shell.

In several soundings and dredgings to the southwest of the Canaries we got very many large pieces of a branching Gorgonoid which were deeply coated and impregnated with manganese. This was in a depth of from 1100 to 1575 fathoms.

In 670 fathoms, off the Desertas, the dead shells, pieces of coral, Polyzoa, etc., were all coated with a thin film of the peroxide of manganese; and we have had indications of the same thing in still shallower water.

In some of the Radiolarian oozes, and in other deposits, we have found the manganese more abundant in the upper layers than in the lower, and *vice versâ*.

The following are the localities where we have met the manganese in greatest quantities:

Off the Canary Islands; Mid-Atlantic, between Canary and Virgin Islands; southwest of Australia; north and south of the Sandwich Islands; north of Tahiti; generally in the South Pacific in our course between Tahiti and Valparaiso.

Further observations may show that manganese abounds in those places where we have much of the débris of augitic lavas.

7. *Abyssal Rhizopods, Bathybius.*—The manganese nodules, sharks' teeth, etc., which we got in our deepest trawlings have very frequently small branching tubes, composed of clay and sandy particles, running over their surfaces. These belong to a Rhizopodal organism. The sarcode which fills these tubes contains many large brown pigment-cells, and small bioplasts are collected in clumps at distances along the length of the tube, or are scattered throughout it.

Tubes of a similar nature, but composed of pieces of *Globigerina*, Radiolaria, etc., would appear to be rather abundant on some of the oozes, and to run irregularly over the bottom.

In the clays we always get some arenaceous forms of Foraminifera when there has been a successful haul with the trawl. Their shells are made up of pieces of manganese, clay, and small mineral particles, and they contain the same kind of sarcodic substance as the tubes above referred to.

An attached calcareous form (c. f. *Carpenteria*) has been found in rather deep water, and Biloculinas, Nodosarias, Triloculinas, and other forms have been frequently procured alive. These last have orange-colored pigment-cells, in which respect they resemble surface Rhizopods. A living specimen of *Orbulina* or *Globigerina* undoubtedly from the bottom has not yet been met with.

In the early part of the cruise many attempts were made by all of the naturalists to detect the presence of free protoplasm in or on the bottoms from our soundings and dredgings, but with no definite result. It was undoubted, however, that some specimens of the sea-bottom preserved in spirit assumed a very mobile or jelly-like aspect, and also that flocculent matter was often present.

Mr. Buchanan determined that the flocculent matter was simply the amorphous sulphate of lime precipitated by spirit from the sea-water.* Subsequently a number of experiments were made upon the behavior of this amorphous precipitate when precipitated with different quantities of spirit and when treated with coloring solutions. The precipitate was also examined alone and mixed up with some of the ooze. The ooze was examined at the same time, and in the same manner, but without having been treated with spirit. The results were briefly these:

(*a.*) When sea-water is treated with twice its volume of spirit or less, nearly the whole of the amorphous precipitate assumes the crystalline form in a short time.

* See a paragraph from Mr. Buchanan's report on the following page.

(*b.*) When treated with a great excess of spirit the precipitate remains amorphous, and assumes a gelatinous aspect.

(*c.*) This gelatinous-like sulphate of lime colors with the carmine and iodine solutions, and when mixed with the ooze has, under the microscope, the appearances so minutely described by Häckel.

(*d.*) The ooze washed with distilled water, or taken just as it comes up, and treated in the same manner with coloring-solution, does not show these appearances. The jelly-like aspect and the matter colored with carmine can always be removed from the spirit-preserved specimens of the ooze by treating with distilled water.

(*e.*) In all cases the jelly-like or mobile aspect of the oozes is found to be due to the presence of the flocculent precipitate from the sea-water associated with the ooze.

(*f.*) No free albuminous matter could be detected.

When it is remembered that the original describers worked with spirit-preserved specimens of the bottom, the inference seems fair that *Bathybius* and the amorphous sulphate of lime are identical, and that in placing it among living things, the describers have committed an error.*

* Mr. J. Y. Buchanan, chemist and physicist to the Expedition, makes the following remarks on *Bathybius* in his Report, p. 605 of the Proc. Roy. Soc., vol. xxiv. Read March 16. In connection with carbonic acid I may mention that I have frequently tested waters, and especially bottom-waters, for organic matter. None of the methods in use for determining this substance in drinking-water giving satisfaction when applied to sea-water, I had to content myself with endeavoring to detect its presence. If the jelly-like organism which had been seen by some eminent naturalists in specimens of ocean-bottom and called *Bathybius* really formed, as was believed, an all-pervading organic covering of the sea-bottom, it could hardly fail to show itself when the bottom-water was evaporated to dryness and the residue heated. In the numerous samples of bottom-water which I have so examined, there never was sufficient organic matter to give more than a just perceptible grayish tinge to the residue, without any other signs of carbonization or burning. Meantime my colleague, Mr. Murray, who had been working according to the directions given by the discoverers of *Bathybius*, had actually observed a substance like "coagulated mucus," which answered in every particular, except the want of motion, to the description of the organism; and he found it in such quantity that, if it were really of the supposed organic nature, it must necessarily render the bottom-water so rich in organic matter that its presence would be abundantly evident when the water was treated as above described. There remained, then, but one conclusion, namely, that the body which Mr. Murray had observed was not an organic body at all; and on examining it and its mode of preparation I determined it to be sulphate of lime, which had been eliminated from the sea-water always present in the mud, as an amorphous precipitate, on the addition of spirit of wine. The substance when analyzed consisted of sulphuric acid and lime; and when dissolved in water and the solution allowed to evaporate, it crystallized in the well-known form of gypsum, the crystals being all alike, and there being no amorphous matter among them.

These observations were made chiefly on the voyage from Hong Kong to Yokohama in the first quarter of the year 1875; and it subsequently occurred to me that an approximate determination of the organic substance in sea-water might be effected in the following way: Supposing the amount of carbonic acid in the water to be known, let a little permanganate of potash be added to a sample of it,

8. *Origin of Deep-Sea Clays. Relative rate of Deposition of Deposits. Conclusion.*—The very wide distribution of pumice, vesicular lava, or light scoriæ has been already alluded to. Some of the bottoms which have been classed under the head of clays, as 2900 fathoms south of Tongatabu, are largely made up of pumice in a fine state of division. Pumice or vesicular lavas have, in short, been found in all the kinds of deposits, most abundantly in the vicinity of volcanic islands and in the deep-sea clays. It appears to be universally present, and its disintegration is most probably the chief source of the clayey matter found in oceanic deposits. North of the Sandwich Islands we for several days got small pieces of pumice floating on the surface, most of the pieces being covered with a fungoid growth. In this connection it may be well to remember that Mr. Bates states somewhere that he found pumice rather common, floating on the surface of the Amazons, over a thousand miles from the nearest volcanic region. Many instances are given by Sir Charles Lyell of volcanic ashes having been transported to great distances by the wind.

At Honolulu Mr. Green informed me that *Pele's hair* had been picked up in his garden there after an irruption of Kilauea in Hawaii, a distance of about 180 miles from the crater. If there be an ash after the carbonate of lime is removed by carbonic acid or other agent, this will be another source of the clay.

Mr. Buchanan has determined in the clays the presence of copper, cobalt, and nickel, in addition to iron and manganese. Remembering this, one is tempted to suggest the presence of meteoric or cosmic dust in these deposits.

When we have had a good haul from a red-clay bottom, when the bag comes up full of nodules, tympanic bones, and sharks' teeth, we cannot resist the idea that we are dealing with things of a vast antiquity, and that we have evidences of a very slowly accumulating deposit. When there has been no reason to suppose that the trawl has sunk more than one or two inches in the clay, we have had in the bag over a hundred sharks' teeth and between thirty and forty ear-bones of cetaceans; some of these have been imbedded in over an inch of the manganese, arranged in concentric layers, while others have had just a trace of manganese on them, or none at all. We have every reason to suppose that the aggregation of the manganese around these relics is a very slow process, and that

and let the carbonic acid be determined in the usual way by boiling the solution. If the water contained any easily oxidizable carbon compound, we should obtain more carbonic acid in the second than in the first determination, and the difference would correspond approximately to the amount of organic carbon present. In several waters which I have treated according to this principle, I have found from two to five milligrams of carbon per liter.

consequently the occurrence of these deeply imbedded and recent teeth and tympanics in the same surface-layers argues strongly in favor of an exceedingly slow rate of deposition. These vertebrate remains are most abundant where the manganese abounds, but occur also in the red and gray clays, especially in those the farthest from the land, and where we may suppose the rate of deposition to be reduced to a minimum.

In the Globigerina, Radiolarian, and Diatom oozes we have found during the whole cruise only one or two sharks' teeth and perhaps one tympanic bone. In shore-deposits they were even more rare. These facts, taken with others that will at once suggest themselves, go to show, as might be expected, that the shore-deposits accumulate faster than the organic oozes, and these last faster than the deep-sea clay. The organisms in our Radiolarian ooze appear to resemble very closely, and in their relative proportions, those described from the Barbadoes earth. Those described from the Oran deposit in Algeria are very like those in the blue muds taken along the course of the Japan stream. The Globigerina-oozes which we get in shallow water resemble the chalk much more than those in deeper water, say over 1000 fathoms. It is possible that deposits similar to those taking place in deep water, far away from the great continental anticlines, may never have been elevated into dry land.

In conclusion, large quantities of the various bottoms have been stored with a view to future work, and a large amount of material bearing on the subjects treated of in this Preliminary Report have been accumulated. When these come to be carefully examined and compared, with the aid of appliances and conveniences not to be had on board ship, many of the statements herein made may require to be altered and amended, and other facts and relations, more curious and interesting than any hinted at, may be revealed.

ART. XXXIII.—*On Gmelinite from Nova Scotia;* by A. B. HOWE. (Contributions from the Sheffield Laboratory. No. XLII.)

WHILE in Nova Scotia, during the summer of 1875, our party found this comparatively rare mineral in considerable quantities, but of two very distinct and different habits. In order to see if this difference of habit could be accounted for by any difference in chemical constitution, the following analyses were made.

The first variety is from a locality called Two Islands, and presents the general appearance very closely of that from Cape Blomidon, which is nearly opposite to this locality. The rhombohedral planes, *R* and -1, are very nearly equally developed, and the lateral planes *i* are very distinct and are striated horizontally. The basal plane *O* is developed to a varying extent in different crystals, but is plainly discernible on all, unless the crystal is imbedded in the matrix or in another crystal so as to conceal it. The plane 1-2 is occasionally seen and usually has a slightly hollow or concave form, and sometimes is represented by simply a slight groove or line along the edge formed by the intersection of the planes *R* and -1. The color is a pale flesh-red or a cream-white.

In the variety from Five Islands, a locality distant about eight miles from Two Islands, the general appearance is very different, resembling very much that of acadialite. The planes are nearly the same as in the Two Islands variety, but their relative development is very different. The basal plane *O* is wholly wanting, and the plane -1 is extremely minute in most cases, being hardly discernible on some crystals. The lateral planes *i* are still present, or rather a series of them, each individual being small and brilliant, having lost their horizontal striations. One of the most characteristic planes is that truncating the edge between *R* and -1. This plane 1-2, is distinctly striated parallel to its intersection with the plane *R*, and is always present, even on the smallest crystals, although in some cases it is very much broken and deeply striated. The whole crystal presents the general form of a nearly perfect rhombohedron, some of the faces being nearly perfect, while others are made up of a number of minute crystals, forming an uneven surface. The color is much deeper and brighter than that of the other varieties. On some of the larger crystals there is evidence of twinning, but these have not yet been examined to ascertain if they are true twins.

In order to compare the composition of the Nova Scotia mineral with that from Bergen Hill, an analysis of the latter was also made, but on account of the lack of sufficient quantity it was not made in duplicate. The habit of this variety was intermediate between the other two. The rhombohedral planes *R* and -1 are unequally developed though to a less extent than the Five Islands variety, and the basal plane *O* is wanting. The prismatic plane *i*-2 was not observed on any of the crystals, although some of the Bergen Hill specimens showed an apparent tendency to put on this plane.

The following angles were measured directly with an application goniometer, and agree pretty closely with those given in Dana's Mineralogy:

$R \wedge R = 112° 27'$, $O \wedge R = O \wedge -1 = 140° 7'$, $R \wedge 1\text{-}2 = - \wedge 1\text{-}2 = 161° 10'$,* $R \wedge -1$ pyr. $= 142° 20'$, $R \wedge -1$ bas. $= 79° 27'$.

The following are the results of the three analyses:

Two Islands variety.

			Mean.
Silica	51·36	51·35	51·36
Alumina	17·85	17·77	17·81
Ferric oxide	·15	·16	·15
Lime	5·66	5·70	5·68
Soda	3·90	3·94	3·92
Potash	·24	·21	·23
Water	20·96	20·97	20·96
	100·12	100·10	100·11

Bergen Hill variety.

Silica	48·67
Alumina	18·72
Ferric oxide	·10
Lime	2·60
Soda	9.14
Potash	trace
Water	21·35
	100·58

This analysis is inserted between those of the Two Islands and the Five Islands varieties because it is intermediate between them.

Five Islands variety.

			Mean.
Silica	50·47	50·44	50·45
Alumina	18·26	18·29	18·27
Ferric oxide	·16	·17	·17
Lime	1·13	1·10	1·12
Soda	9·75	9·83	9·79
Potash	·19	·21	·20
Water	20·72	20·71	20·71
	100·68	100·75	100·71

These three analyses give the following atomic ratios respectively:

	Na(K) : Ca,	Ca : Al,	R : Al : Si, (2 Na=R)	Si : H.
Two Islands	1·2 : 1	1 : 1·7	·97 : 1 : 4·9	1 : 2.7
Bergen Hill	6·1 : 1	1 : 4	1 : 1 : 4·5	1 : 2·9
Five Islands	15·4 : 1	1 : 8·8	1 : 1 : 4·7	1 : 2·8

The ratios which Rammelsberg gives as the theoretical are R : Al : Si=1 : 1 : 4 and Si : H=1 : 3.† On comparing these

* Five Islands. The others from Two Islands. Calculated from measurement of 1-2 ∧ 1-2.

† Rammelsberg's Handbuch der Mineralogie, p. 626.

analyses with those given by Rammelsberg, it will be seen that, like the majority of those, they give an excess of silica over that required by the ration 1 : 1 : 4. This excess is very marked in the Nova Scotia varieties, but in these it may be partly accounted for by a slight decomposition which may have taken place. The Bergen Hill crystals, however, were very evidently sound and undecomposed, and the excess in this case can not be accounted for in that way.

Both the Nova Scotia varieties had apparently undergone a slight alteration. The crystals were somewhat porous and hollow, and thus would be exposed to easy decomposition; or this structure may have been the result of alteration. Thin sections examined under the microscope with polarized light afforded no evidence of free quartz. If the bases had been removed during decomposition, they had been removed in the proportion in which they existed in the mineral originally, for the ratio of R : Al is closely alike in all the varieties. The excess of silica may have been left in such a form by the decomposition that it would not show itself under the polarizer. The crystals from Bergen Hill however were perfectly sound and unaltered. They gave a very perfect hexagonal and also a basal cleavage, as did the other varieties though not so easily as this. The basal cleavage is not so readily obtained as the prismatic. On treating the finely ground mineral with hydrochloric acid, decomposition with separation of finely-divided silica took place, but there were no traces of gelatinization.

Several experiments were made on the loss of water by heating, but with no satisfactory results. The mineral, even when in coarse fragments, loses weight steadily in dried air at the ordinary temperature. At the end of eleven days over oil of vitriol it had lost about 4 per cent and was still losing at a nearly constant rate. After two days drying at a temperature of 100° C., a constant weight was reached which gave a loss of 7·65 per cent. A constant weight was obtained at a temperature of 115°–120° C., giving 8·82 per cent loss. Another was also found at 160°–180° corresponding to a loss of 17·02 per cent. Still others were found at 200°–210° and at 250° equal to 19·42 and 20·40 per cent respectively. At every temperature mentioned the loss was rather rapid at first, gradually becoming slower and slower till a constant weight was obtained. Apparently the mineral possesses the property of giving a constant weight at any temperature, which may account for the very various results which other experimenters have obtained. The water is driven off completely at a red heat, and the powder becomes sintered together into a mass but without absolute fusion.

It is interesting to notice the fact that the habit of crystalli-

zation corresponds to the difference in chemical composition, at least so far as these three varieties are concerned. In the specimens from Five Islands, in which the protoxide bases are almost wholly made up of soda, the crystal is decidedly rhombohedral in character; the plane -1 is exceedingly minute and the basal plane O is wholly wanting. In the Bergen Hill crystals which were used in the analyses, and are intermediate in composition between the other two, the crystals have not so decidedly a rhombohedral appearance, although R and -1 are very unequally developed. In the crystals from Two Islands, where the lime nearly equals the soda, the planes R and -1 are very nearly equal in size and the basal plane O has made its appearance. The question what change in the crystalline habit a further increase of lime would produce is an interesting one, but must remain unanswered till specimens containing more lime are analyzed and described.

ART. XXXIV.—*On the occurrence of Durangite in the tin-bearing region of Durango, Mexico;* by HENRY G. HANKS.

UP to the present time no account of the mode of occurrence of durangite has been published. Although I have made persistent effort to learn some facts bearing on this subject during the last seven years, since the first description appeared in this Journal, I have never been able to obtain anything reliable until now.

It has been stated in a general way, that this rare mineral was found with stream tin in Durango, Mexico; but as the hardness of durangite is only 5, it has heretofore been impossible to account for the perfect state of the crystals as they reach us.

I am able at last to throw some light on this subject, deriving my information from Mr. J. F. Boyd, of Durango, and Mr. Ayres, of Coneto, Mexico, both of whom have lately visited San Francisco. According to these gentlemen, durangite has been found only in the "Barranca" tin mine and never in the beds of streams. The tin fields in which this mine is located lie about eighteen miles northwestwardly from Coneto, State of Durango, Mexico, and about ninety miles in the same direction from the city of Durango. This would locate them nearly in lat. 23° 30′ north, long. 104° 30′ west. The mines are embraced in a circle which could be swept by a radius of thirteen miles. The whole area is cut up by arroyos, varying in width from ten to one hundred and fifty feet, and of unequal depth. In the beds of these arroyos, through all of which water runs during a por-

tion of the year, and in a few of them during the whole of the year, stream tin is found underlying sand and gravel. The tin ore is sometimes found in bars or flats, sometimes mixed with the surface earth; but generally at a depth of six to ten feet beds of tin pebbles are found. In exceptional cases deposits two feet in thickness have been uncovered, presenting the appearance of a gravel pavement.

Crossing the arroyos, veins of tin occur in threads and seams, from a few inches up to several feet in thickness. All the larger veins have smaller and richer ones intersecting them. One well-known vein is from forty to sixty inches thick, yielding from twenty to twenty-six per cent of tin stone, while the smaller veins crossing it produce as high as sixty-eight per cent with the same treatment.

The tin ore is invariably found in what Mr. Boyd describes as a "whitish cement" which softens readily in water, allowing the cassiterite to fall to the bottom of the washing troughs. Mr. Boyd thinks the character of this formation controls the purity of the tin. When it has a yellowish shade he expects to find the tin contaminated with arsenic, iron, and bismuth. If light gray or white, he notices that the vegetation is stunted, but the character of the tin produced is much improved. Ores yielding from eighteen to thirty per cent are very abundant, but do not pay to smelt without concentration. Associated with the tin ores are found fluor spar, calcite, chalcedony, and topaz.

The altitude of these tin fields is from nine thousand to ten thousand feet. All the hills are beautifully overgrown with grass and shrubbery. The mines occur in a crust of a lighter color than that of the general country. This formation is from seven hundred to twelve hundred feet in thickness overlying the gold, silver and lead-producing formation. Sometimes a high hill or mountain top is seen to be capped with the tin formation.

Over the entire tin fields prospecting holes have been sunk, the bed rock being reached at a depth varying from three to ten feet. These shafts have never failed to develop stream tin in greater or less quantities. During the wet season, commencing in the middle of June, great quantities of rain fall. Advantage is taken of the abundance of water to sluice out the stream tin, to be smelted during the dry season. The smelting is done in a rude way in furnaces built of adobes, yet it is stated that metallic tin can be produced at a cost of two cents per pound. The tin ore is found loose in the veins in irregular rounded masses, from minute sand-like particles, to pieces the size of a man's head. A curious form resembling small cylinders or stalactites is not uncommon.

Mr. Boyd estimates the number of veins known at six hundred, and the number of streams or arroyos yielding stream tin

at three hundred. This gentleman thinks that the tin ore is still forming. He assures me that work having been suspended on a mine in 1864, a portion of the vein was left standing. In 1870 he visited it again and found that new films or layers of cassiterite had formed, and in some places noticed that peculiar variety known as toad's-eye tin which he believes had formed during his absence.

These mines were discovered and worked on a small scale by the Spaniards from 1790 to 1824. From 1835 to 1846 they have been worked by Don Manuel Gracia, a native Mexican of Spanish descent, who amassed a fortune by extracting the tin and carrying it on mules to the city of Mexico, 590 miles distant.

Barranca is the name of a group of small veins rather than that of a single one. The vein in which the durangite is found is from four to six inches in thickness. It rises from a deep cañon, is nearly vertical, dipping but slightly. The fissure is filled with loose vein matter containing cassiterite in cylindrical pieces, quite small. Crystals of durangite occur singly with cassiterite in the white pulverulent matter before described. Beautiful crystals of a larger size and of a light orange color are sometimes met with attached to the walls of the vein. I have a few of these in my collection; they are quite different from those found in the vein matter. It was this variety which was first described by Prof. Brush.

The vein matter is described as being highly charged with arsenic. When thrown into the furnace, so abundant are the arsenical fumes evolved that the workmen cannot endure them, and a preliminary washing process is resorted to, by which a large proportion of the arsenical matter is removed. Sometimes in washing the vein matter, crystals of durangite are found, as are also those beautiful topaz crystals which have found their way to the cabinets of mineralogists in all parts of the world.

I understand Mr. Boyd to say that the crystals of durangite are only occasionally met with. The largest crystal known is now in my possession. It weighs 3·022 grams. Its greatest length is 19 millimeters and its extreme thickness 11 millimeters. The edges are sharp and all the angles well defined and perfect. There are some imperfections on some of the faces. It is of a beautiful orange-red color, resembling bichromate of potash.

The crystals found in the vein matter are usually small, and of a darker color. On weighing one hundred of them to ascertain the average, I found their combined weight to be only 7·750 grams.

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ART. XXXV.—*On the occurrence of Grahamite in the Huasteca, Mexico, and Notice of the Geology of that Region;* by JAMES P. KIMBALL, Lehigh University, Bethlehem, Pa.

THE descriptions of the albertite deposit of Hillsborough, New Brunswick, by Professor C. H. Hitchcock,* and of the grahamite deposit of the Ritchie Mine in West Virginia by Mr. W. M. Fontaine,† as well as by Mr. Henry Wurz,‡ show these deposits to widely differ from any known, or even possible, occurrence of mineral coal, from the nature of which albertite and grahamite have been shown by Wetherill, Wurz, and others, likewise to differ essentially. Both varieties occur in the state of Vera Cruz, Mexico, under such circumstances as to exhibit well the nature and proximate origin of such deposits.

A closer comparison of the two varieties, by means of a more extensive series of analyses than has yet been published, is required to fix the exact relationship between them. As distinguished by physical properties, they seem to pass into each other by insensible gradations, especially in the Ritchie deposit, and in such of the Mexican deposits as I have seen. Such analyses as are at hand, of specimens from one and the same deposit, indicate inconstant ratios in each variety—evidently depending on the degree of oxidation. This variableness shows that neither variety is a true mineral species, any more than other native hydrocarbon compounds, like petroleum, asphaltum, or mineral coals. The following observations serve to confirm the received theory of the nature and origin of albertite and grahamite, and to demonstrate that these bodies are essentially mineralized or fossilized asphaltums, derived from asphaltic petroleum, pittasphalt or maltha, by the loss of hydrogen and the addition of oxygen. In the degree of this alteration albertite seems to occupy a place between asphaltum and grahamite—the two varieties, however, constituting a single mineral type. The degree of oxidation of such compounds does not always correspond to the amount of retained or fixed oxygen—a large proportion of the increment of oxygen forming volatile compounds along with carbon and hydrogen, especially in the more advanced changes which result in their conversion to such anthracitic bodies, low in oxygen, as are often found in cavities of the rock in the older formations.

Numerous springs of asphaltic maltha, forming in places superficial deposits of solid asphaltum, occur on the eastern slope of the Cordilleras of Mexico, or rather, in the littoral zone

* This Journal, xxxix, 1865, 26–7.
† Ibid., vi, III, 1873, 409. ‡ Ibid., xlii, II, 1866, 420.

toward their base. A small lake fed by a spring of bitumen is reported to occur as far north as Galveston Bay in Texas within the Tertiary area.* More or less extensive sources of the same substance are common throughout the large area watered by the numerous streams discharging into the Tampico and Tuspan rivers, at whose mouths are the gulf ports of Tampico and Tuspan. A considerable quantity of chapapote, as it is called, is brought down by these streams, washed out to sea, and finally left upon the beach by the action of the waves. After such a thorough exposure to the elements, it loses its pitchy consistency, and becomes brittle and lustrous like jet. It has then a conchoidal fracture. In this condition it is sometimes gathered, and, though not extensively known, is highly esteemed as an article of export.

The northwestern portion of the state of Vera Cruz is known as the Huasteca, which may be described as the area south of the Panuco River, embracing the territory to the north of the plateau of Anahuac, watered by the three forks of the principal affluent of the Panuco—the Rio San Juan de Mexico—namely, the Capadero, the Amajaque and the Moctezuma. This section has received no attention from scientific travelers. In 1825, Burkhart, traveling from Tampico to Real del Monte, via Tantoyuca, passed along the upper Capadero. This river he mistook, however, under the name of the Rio Garzes, and supposed it to have an easterly, instead of a northerly, course, and to empty into the Laguna de Tamiagua. Saussure's map of the plateau of Anahuac represents this portion of Mexico with some approach to its geography, if not to its topography.†

Last April I made the journey from Tampico to Tempoal on the Capadero, crossing the Topila at Tanseme, and returned to the same port by way of Trinidad and Panuco. The topographical features of the country, which thus came under my observation, are not unlike what I have described to be the character of the eastern slope of the Cordilleras farther north as observed in Chihuahua.‡

The same succession of longitudinal valleys separated by parallel ridges is here seen, together with the same gradual acclivity toward the summit of the Sierra Madre, which in this latitude is about Zacatecas. The valleys, though broad, are, unlike the champlain valleys of Chihuahua, comparatively rugged, owing to the uneven erosion of the sedimentary rocks, which is caused by intrusions of trachyte. Their configuration is largely due to the successive changes of the beds of streams,

* Taylor, Statistics of Coal, p. 498.
† Coup d'œil sur l'hydrologie du Mexique, Geneva, 1862.
‡ This Journal, xlviii, 1869, p. 385.

caused by the gradual elevation, or periodic oscillations of level, of the Cordilleras during the Tertiary period and afterwards, and which phenomena, as I have elsewhere noted, are likewise strongly marked in northern Mexico.*

The area over which my route lay, is occupied by argillaceous sandstone, calcareous in places, whose foldings seem, generally speaking, to correspond with the present configuration of the surface, the whole of which, however, has been subjected to a very powerful erosion. One of the most remarkable evidences, both of the gradual character of the elevation of the Cordilleras in the lower latitudes, and of the fluvial character of their erosion, is to be seen in a widespread alluvium, composed of coarse gravel and heavy rolling stone in the valley of the Capadero, observed many miles away from the present channel of the river, wherever its heavy covering of fine silt-like alluvium has been washed away. Through these two superficial deposits successively the river has cut its present channel deep into a formation of soft shale beneath, locally known as *tepetate*, which overspreads the whole valley of the Capadero.

The shale is highly fossiliferous in places. Imperfectly indurated and weathering excessively, it causes the fossils to crumble. They include *Cardium*, *Arca*, *Ostrea*, *Corbula*, *Pecten*, *Caryatis*, *Serpula*, and a discoid, coiled and chambered rhizopod. With the exception of the last, all are too imperfectly preserved to admit of specific determination. Common to both the Cretaceous and Tertiary as these genera are, such specimens as I was able to extract fail to distinguish between these two periods. In a private report, written without access to my collection, the shales were referred to the Cretaceous upon the grounds of the apparent facies of these specimens. They prove however, upon examination, to be wanting in characteristic types, and too uncertain of specific identification to rest any conclusion of the kind upon them, especially as the stratigraphical relations of the shales themselves indicate, as I shall presently show, an unbroken and immediate sequence with alluvial Quaternary deposits. Arguing from the latter circumstance, it will be seen that they are more logically referred to the Tertiary. These shales are important as the seat of the grahamite deposits in the vicinity of Tempoal, and probably throughout the much larger region of the Huasteca, including, at least, the middle portion of the Capadero basin, or so much of it as lies between the Huejutla Mountains on the west and the Alacranes hills on the east. The region thus defined corresponds to the so-called "Coal-field of the Huasteca," the coal, however, as I judge from

* This Journal, xlviii, 1869, p. 381.

such specimens as I have seen, really being grahamite and other less thoroughly altered asphalts.*

Judging from a number of specimens of these outcrops from farther up the Capadero than the district visited by me, as well as from such facts as I could gather by inquiry, it seems most probable that the shales of Tempoal and of the Cristo Mine, which came under my observation at these and other points in the banks of the Capadero, extend, at least, some 60 miles farther up the river, as far as Chalma, so as to include the so-called coal deposits at the base of the Cochiscuatitlan hills mentioned by Antonio del Castillo, viz., Purisima, Providencia and Virginia. A specimen of grahamite, now in my possession, from Huautla, 50 to 60 miles still farther up the river, suggests a still greater extension of the same shales, found to be the seat of grahamite at Tempoal and elsewhere.

Except in the banks of the river, and the beds of branching arroyos, the grahamite-bearing shales nowhere come to the surface in the Capadero basin, within the range of my observation, although not far below the level of the valley-plain, or lower terrace of the river. Together with grahamite, they are reported, and may be readily believed, to outcrop in the Huejutla Mountains, as at the Venados, where a deposit of the former was described by the messenger sent thither for specimens, to be upward of two feet in thickness.

The shales are immediately covered by the above mentioned deposit of coarse rounded rubble, generally more or less cemented by selenite so as to form a conglomerate from 3 to 6 feet thick, and containing shells of *Paludina*. This is immediately overlaid by the heavy deposit of fine alluvium, the least thickness of which, as seen in the river banks, is some 60 feet. It overspreads the whole valley in the vicinity of Tempoal, as well as of the Aguacates, some 12 miles farther up the river.

In the vicinity of Tempoal, where alone my examinations have been special, the top of the shales is generally brought by undulations above low water mark—that is, above the level of the river in the dry season. Near the village, it rises some 30 feet above this level; at the Parajes, two miles below, some 25 feet; at the Aguacates, 12 miles above, some 60 feet; while at the Cristo Mine, it is near the water's edge, though rising directly on either side. We have as yet no data bearing on the thickness of the shale, as its edges are everywhere concealed—if not by overlying alluviums—by a detritus resulting from its own weathering, as it slacks at once on exposure to the air.

* Some attention of late, in the City of Mexico and elsewhere, has been turned to this region upon the strength of rather venturesome computations of the extent and value of the alleged coal deposits, based upon unexplored outcrops of what is assumed to be beds of bituminous coal. (*Compania Explotadora de Criaderos de Carbon de Piedra.* Mexico, 1876. A report by Antonio del Castillo.)

At Tempoal, at the Cristo Mine, and at the Aguacates—three out of five points where I have observed exposures of the shales in the banks of the Capadero, grahamite is found in greater or less quantity. Like many similar Tertiary sediments, the shales are in places quite gypsiferous.

Remnants of these Tertiary shales are to be seen in the banks of the Panuco at Puebla Vieja, near the mouth of that river. The same formation seems to answer to Burkhart's description of the formation occupying the Garzes, (Capadero) valley as high up as Chapula, and even still higher, as far as a little south of Pinolco, with occasional protrusions of the lower sandstone series—including beds of limestone, as between Huautla and Tlacolula, and again, south of Zagualtipan.*

According to this traveler, the clay shale of the valley about Chapula apparently overlies unconformably the limestone, which he believed to be the upper member of the sandstone series, forming the heights all the way from the coast, except where covered by trachyte. The mesa tops of the mountains just west of Chapula are of the latter volcanic rock, which likewise seems to form the summits along the whole range to the north. Approaching the volcanic plateau of Anahuac, the whole body of sedimentary rocks—together with overlying trachyte, was observed by Burkhart to decline to the south and to pass beneath the diorite and basalt of the table-land, which was geognostically mapped by Gerolt and Berghes in 1827.†

Mention is made by Sr. Castillo of the discovery of an "hexagonal" sigillarid as well as nummulitic forms in the so-called coal-bearing rocks of the Huasteca. The sandstone series, in whose depressions the Tertiary grahamite shales have been preserved from a sweeping denudation, has furnished a few fossils at Tampico, where it has been quarried. I succeeded, however, in finding none but fragmentary gasteropods, though perfect specimens of the same are said to be preserved in private collections there, which it has not been my privilege to see. So doubtful is the existence of true coal in the Huasteca, that the alleged discovery of palæozoic fossils, as claimed in Mexico by way of confirmatory evidence, as I infer, of the carboniferous age of the sandstone series—requires the support of other facts. It is proper to remark that in the interior of the country, the rock surfaces are absolutely unbroken, while covered with a tropical forest; hence the present impracticability of a successful search for fossils in this part of Mexico.

Burkhart also identified in the banks of the "Rio Grande" (Amajaque) the same formation of clay shale observed by him

* Aufenthalt und Reisen in Mexico in den Jahren 1825 bis 1834. Stuttgart, 1836. I, p. 53.

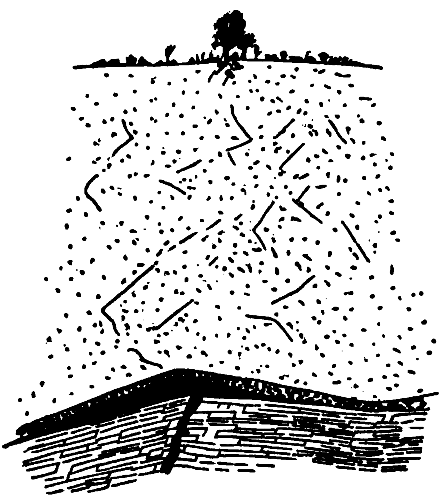
† Carta Geognostica de los principales Distritos Minerales del Estado de Mexico, 1827.

between Chapula and Pinolco in the Capadero basin, and thence inferred the geological identity of these neighboring basins.

I now proceed to describe the deposit of grahamite known as the Cristo mine.*

The original outcrop of the deposit appeared at the base of the west bank of the Capadero, on the Cristo Ranch, near the edge of the river at low water, and below the surface of the water during the rainy season. It appears to have been long observed, and to have been regarded by some persons as a deposit of bituminous coal, and by others as chapapote, but to have remained unexplored—perhaps through some discovery of its ill adaptation to the ordinary purposes of either fuels or asphalts. In 1873, the deposit was denounced as a coal-mining property.

The deposit consists of two continuous parts, the one occupying a nearly vertical fissure traversing the fossiliferous shales, and the other part conformably overlying these shales, which are slightly inclined. We have here the phenomena, first, of a deep-seated fissure transverse to the bedding of the formation, and filled out with grahamite; and, second, a nearly horizontal, and originally superficial, deposit of the same material overspreading the shale formation for a limited distance from the fissure. The latter occurrence is an overflow from the fissure, and, as it lies between the two formations, is to be referred to a period subsequent to the deposition of the shales, and before the conglomerate was spread upon them in the form of pebbly detritus. It thus happened when the shales formed the surface at this point, just as asphaltum is now commonly formed upon the surface, as a residuum from the evaporation and oxidation of liquid or pasty malthas, issuing from sluggish springs, or oozing from more extended sources, as from a certain stratum or rift in the rocks. Such phenomena, referable to the sandstone below, are to be seen beyond the boundaries of the shale formation in the neighborhood of the Cristo mine, and indeed are quite



* J. P. Kimball on a deposit of grahamite known as the Cristo Coal mine, with plate. 24 pp. 1876.

common in the surrounding portions of eastern Mexico, as already observed.

That portion of the overflow which originally appeared at the base of the river bank, has now been worked out, 210 tons having been quarried and shipped. So far as can now be ascertained, the overflow was altogether west of the fissure, which has a width, as far as developed, of 34 inches. The vein occupying the fissure has a columnar structure transverse to its sides, and shrinkage partings, or joints, parallel to its sides. It has thus far proved remarkably homogeneous in structure, and free from admixture of rock or clay. Its dip is 64° to the W. Near the point where it passes out of sight under the river bed, it is joined, at an acute angle, by a narrower and tapering vein of which the maximum width is 9 inches. According to those who have had charge of operations at the Cristo mine, the deposit, including both vein and overflow, was excavated within a dam to a depth of ten feet, and, at the same place, measured fifteen feet across. The vein proved of the same width as observed by me nearer the bank—that is, thirty-four inches. This point, now under water, was stated to be 120 feet from the base of the latter. Another small branch is partially seen on the opposite side.

The shape of the overflow is indicated as near as is now practicable, by the excavation outside of the bank and by the work underground. The latter consists of a timbered shaft, 72 feet deep, sunk from the top of the river bank or terrace, 196 feet from the edge. From the bottom two levels have been run out at right angles, one 19½ feet long toward the river (east), and the other 27½ feet long toward the north. These workings are in that portion of the deposit which for convenience I call the overflow. Its greatest thickness is developed in the east level, at the end of which it measures 6½ feet and dips 19½° S. W. At the end of the north level it has a thickness of but 15 inches, and a dip of 20° to the northeast. In the shaft the thickness of the deposit falls from 34 inches at the southeast corner, to 15½ inches at the opposite N. W. corner, to 20 inches at the S. E. corner, and to 15 inches at the N. E. corner. It therefore appears that the overflow of the vein has a limited spread underground, the same as it proved outside the bank at the water's edge. Its thickest portion is in the direction of the river, and continuous, I think, with the thickest part of the original outcrop; that is, the portion nearest the fissure, which was undoubtedly its source, and from which it sloped with the configuration of the surface at the time, and thinned away toward its edges. The fissure occupies the axis of a gentle anticlinal with a dip of 14° W. on the W. side, and of 4° E. on the opposite side. As the overflow conforms to the steeper dip,

it appears that the fissure must have been made at the time of the elevation of the shales, and soon afterwards filled with asphaltum, which continued to form after it had been filled. That no great period was required for this operation, is shown by the fact that the overlying conglomerate also conforms to the stratification of the shales as well as to the outline of the overflow of the grahamite, locally intervening.

The occurrence of such a fissure in shales so imperfectly hardened, and so easily weathered, affords another proof that the filling of the fissure immediately followed its formation, that is, after the emergence of the shales and before the deposition of the overlying alluvium. It is from this evidence of the direct sequence of terranes, and the relation thus established with subsequent alluviums that, in the failure of the evidence of their fossils, I refer to the Tertiary the grahamite-bearing shales of the Capadero basin. These are probably remnants of the littoral Tertiaries of eastern Mexico and Texas.*

The strike of the fissure is nearly north and south, directly across the river. No attempts have been made to trace it beyond the excavation near the water's edge, its character as a fissure not having been recognized previous to my visit. A length of about 300 feet upon it had at that time been developed.

The sandstone formation is the source of a number of deposits of chapapote or asphaltum. Numerous deposits are said to occur north of the Panuco River. One deposit, which I visited, is found on the Tanelul Ranch, occupying an elevated basin or cul-de-sac between two hills of the Alacranes range, here forming the boundary of the Capadero valley. The point is some 2¼ leagues east of the Cristo mine, and *directly in range with the course of the Cristo fissure as far as traced.* The chapapote has accumulated from the evaporation of liquid maltha, which now issues in the form of a sluggish spring with a number of orifices. Here may be witnessed the same process by which the above described overflow of the Cristo mine was originally formed. The source of the chapapote spring is the sandstone above mentioned, on which rest the grahamite-bearing shales of the valley below. It thus appears that the uplifted portions of the underlying sandstone are at present the source of chapapote springs depositing that mineral substance upon the surface. Ancient, and perhaps more copious, springs of the same kind issued from the depressed portions of this formation, and forced their liquid maltha into the fissures and lesser interstices of the overlying shale, which, as I have already stated, is remarkably cleavable and imperfectly indurated. The tendency of such a body of shale or shaly clay, exceedingly fine in texture, to form

* Archiv de la Commission Sc. du Mexique, ii, p. 124.

shrinkage and cleavage partings is well known. Hence this formation, from its nature otherwise impervious, became the permanent receptacle of maltha or asphaltic petroleum, issuing from the sandstone below; and probably the more freely under a hydrostatic pressure, in which water played a part, and the action of which is strikingly suggested by the configuration here observed of a stratigraphical basin bordered by elevated plateaus. The inspissation of maltha or pittasphalt, and even petroleum, to grahamite and other mineral bitumens, by the loss of hydrogen and the addition of oxygen, is a well known occurrence which may be artificially illustrated in the laboratory.* While asphaltum is observed to be the product of the immediate evaporation and oxidation of maltha at or near the surface, a slower and continued oxidation beneath the surface —in fissures, cavities and interstices of the rocks—has produced grahamite, albertite and other less hydrogenous hydrocarbons of the same type.

The smaller exhibitions of grahamite in the shale of the river banks, at Tempoal and the Aguacates, are of the same general nature as the deposit of the Cristo mine. They occupy interstices between divisional planes of the formation, thus forming veinlets which often pass from between one kind of partings to another. Hence even the larger of these deposits or pockets are very capricious in position, while the smaller ones merely reticulate the rock. They seem to have no connection or channels. The question is thus suggested, whether this formation, in places densely filled with organic remains, has not, in part at least, been the primary source of the hydrocarbons which it contains, as well as those of the underlying sandstone, from which, since its emergence, it has been for the most part denuded. This theoretical question must remain open until the relations of the numerous deposits of chapapote in eastern Mexico to the rocks from which they spring, shall be observed and compared. The above small and scattered deposits of grahamite have no economic value—although fine hand specimens can be taken from any of them.

Unlike the New Brunswick variety, which is compact in structure, conchoidal in fracture, and of a resinous and brilliant luster, the Ritchie and Cristo varieties, which are very similar, are of rather granular consistency. They possess a very distinct cleavage, a jointed structure, as well as columnar partings in the deposits, somewhat irregular, on account of the varying conditions of these deposits themselves. The Cristo mineral is more uniformly lustrous than that from Ritchie County, and of a greater coherence, though none the less distinctly cleaved and jointed.

* W. P. Jenny, Am. Chem., v, p. 10.

Both varieties are found at the Aguacates in veinlets. Some of these are filled with a conchoidal variety, like that from the Albert mine, while others consist of the same columnar and sub-conchoidal material as that from the Cristo mine. The conchoidal fracture in both differs simply as to degree, varying with the degree of brittleness.

A few barrels of the mineral from the Cristo mine having been sent last autumn to Glasgow, an analysis and technical examination of the sample were made by Mr. William Wallace, of that city.

ANALYSIS OF CRISTO-GRAHAMITE.

Specific gravity .... 1·156.

Volatile matter	Illuminating gas	61·32	62·14
	Sulphur	·46	
	Water	·36	
Coke	Fixed Carbon	31·63	37·86
	Sulphur	·37	
	Ash	5·86	
			100·00

ANALYSIS OF COKE.

Carbon	83·56
Sulphur	·98
Ash	15·48
	100·00

ART. XXXVI.—*On a "Geological Chart of the United States east of the Rocky Mountains, and of Canada;"* by FRANK H. BRADLEY.

IN publishing a new compilation of the general results of geological surveys of the eastern United States and Canada, the writer has felt under obligation to state the reasons for the adoption of any peculiar features of the chart, and also desirous of noting some theoretical points to which this revision of data has called attention.

Mercator's projection was adopted, in order to show most accurately the general trends of the outcrops. The consequent distortion prevented the use of the ordinary mileage scales; but the average scales, for every two degrees, are inserted along the left-hand border.

The scale used is so small that it was impossible to indicate either the very *small* areas of the different formations, or the slighter irregularities of outlines. While this renders the chart inaccurate as regards detail, it has the compensating advantage

of representing with more uniform accuracy areas which have been surveyed with more and with less minuteness.

Considerable portions of the metamorphic areas heretofore mapped as Archæan have recently been proved to be Silurian. These discoveries have cast so much doubt upon the true age of much of the remainder, that I have, in several cases, been unwilling to follow authority in calling it Archæan. The work done in New England by Prof. Dana, and in the Southern States by the writer, has already reduced the Archæan area of the Appalachians by nearly one-half, and has given data for comparison with series of rocks previously described from Virginia, Pennsylvania and New Jersey, which justify the inference that large portions of the metamorphics of these states will also prove to be Silurian. Following this inference, the areas of this region, previously considered Archæan, have been considerably reduced. Much of the uncolored portion of New England is undoubtedly Silurian and Devonian, but with limits which cannot now be determined. Prof. Verrill refers to the Archæan, with much certainty, the belt of red granites running from Mount Desert to the Bay of Chaleur. The Archæan area of northern New York should probably be slightly reduced;* but the age of the principal part of it seems pretty well determined.

The typical Huronian of Canada, according to description, occupies the position, and presents the lithological characters, which we should naturally expect for the metamorphic portion of the adjoining Lower Silurian, corresponding precisely, in both respects, with extensive beds of that age in the Appalachians. I have accordingly colored them as Lower Silurian. After reaching that conclusion, I learned, through Prof. Selwyn, that Sir William E. Logan held the same view for some time before his death, though it is not, I believe, shared by Prof. Selwyn and his colleagues of the Canada Survey. Prof. Selwyn also informs me that recent work of the Survey has shown a continuation of the Huronian belt north of Lake Huron to beyond Lake Mistassini, with a width of over three hundred miles at one point. Considerable portions of the so-called Archæan area of Wisconsin and Michigan have been shown by Brooks and Pumpelly and others, to be the equivalent of the Canada Huronian, for which reason they might with probability be referred to the Silurian; but the data yet published have seemed so incomplete, that the writer has preferred to leave the area uncolored. Both this and the metamorphic area of Minnesota, as yet unexplored, doubtless include some genuine Archæan.

The metamorphics of Missouri are probably Archæan, and are so colored. Those of Arkansas and part of those of Texas

* Brooks, this Journal, III, iv, 22.

are probably Silurian, but not certainly; those of the Indian Territory have, as yet, yielded no data for a conclusion; all these are therefore uncolored.

Sherwood's results, as published by Hall, will require some changes along the north line of Pennsylvania, in future editions: the data did not reach me until this edition had been struck off.

It has long been held that the Appalachian and the Kentucky-Illinois coal-fields were formed in entirely independent basins, having no communication with each other, and consequently no probable equivalency of coal-seams. A glance at the map, showing the close proximity of the two fields in southern Kentucky, must give anyone strong suspicions that this view is incorrect for that part of the country; and examinations of the two opposing escarpments would strongly confirm the suspicions, though we must probably admit the partial division further north, by the Cincinnati anticlinal. In northern Tennessee, the western face of the Cumberland plateau shows the bold outcrop of about a thousand feet of the coal series in regular horizontal position, with no signs of any abrupt thinning out, as thus far observed. Less than sixty miles, across a continuous outcrop of practically horizontal Subcarboniferous strata, brings us to the eastern escarpment of the western field, where the coal-measures are somewhat thinner, at a slighly lower level, and with a less abrupt outcrop, but still undisturbed and evidently only the continuation of beds which once covered the intervening area. I have long taught this continuity of the two fields; and I understand that Prof. Safford holds the same view, while Dr. Newberry, in conversation, strongly opposes it. How far the union continued southward seems difficult of determination. Judging from the broad western extension of the Coal-measures through Alabama, and of the horizontal Subcarboniferous through Tennessee, to the eastern line of what appears to have been a pre-Cretaceous Mississippi valley, together with the great eastern extension of Coal-measures in Arkansas, to the western margin of the same valley, I am inclined to infer a former continuity of the series across the intervening space of 225 miles, and indeed, over the whole area of lower strata in Tennessee, Arkansas and Missouri, with the possible exception of a few islands, such as Newberry suggests for the Nashville basin, (Ohio Geology, i, 96–110). If the Coal-measures were thus continuous, the erosion of the Mississippi valley must probably be referred to the same age (Jurassic?) as that of the Triassic beds on the Atlantic slope, mentioned below.

Wells, dug through the drift of northwestern Indiana,* have yielded considerable masses of Devonian black shale, hardly displaced from contact with the underlying limestone, in such abundance as to lead to the belief that this bed was for-

* **Dr. R. T. Brown, 1869, letter to the writer.**

merly continuous across much of the area which, from the known outcrops, we are obliged to color as mainly Upper Silurian. Indeed, it suggests the probability that the Michigan coal-field may once have been continuous with that of Indiana and Illinois; but the surface of that region is so flat and so deeply covered with drift, that it would hardly be *possible* to obtain the data for a *certain* solution of the problem.

Noticing my own neglect of such points, I am led to ask geologists, generally:—Have we paid sufficient attention to the indications of former *probable* extensions of formations over areas where no portions of them now remain?—a point of little practical importance, perhaps, but certainly of great theoretical interest.

I regret that the scale of the map forbids the representation of the numerous trap dikes, probably of Triassic age, which cut across the metamorphics of North Carolina, South Carolina, Georgia and Alabama. The dips of the sandstones and shales in the two Triassic areas of North Carolina give pretty strong evidence of these being only the border-remnants of a huge ge-anticlinal, over a hundred miles wide,* (the connecting arch being now removed,) which probably extended far to the southwestward, and possibly over much or all of the area intersected by the trap dikes. Kerr's estimates show the erosion of from 10,000 to 25,000 feet of strata, along the back of the fold; and fully as much must be allowed for, between the New Jersey and Connecticut River areas of Triassic if we accept the opposing dips of these as evidence of another, or part of the same, great ge-anticlinal. There are, it is true, strong objections to this view for the latter region; but no other theory seems to the writer so well fitted to meet the facts.

We have, as yet, no certain evidence of distinctively Jurassic strata on the Atlantic slope of this continent; was then the Jurassic the period during which this enormous folding, eruption (and erosion, in part, at least) took place? For the following Cretaceous has apparently been but very slightly displaced, if at all, except by the pretty uniform secular movements of the continental mass. It may also be questioned whether the Permian period, equally destitute of distinctive deposits along the Atlantic border, was not the era of the upheaval and metamorphism of the Appalachians, which was plainly post-Carboniferous and pre-Triassic.

It seems impossible to indicate fairly the Quaternary beds of the continent upon the same chart with the other formations; since, in one form or another, they cover pretty much the whole surface of the country. The marine beds of the period are too small to be of any importance on a chart of this scale; the river- and lake-border formations are sufficiently well *located*

* **Kerr, Geology of North Carolina, i, 141–6, 1875.**

by the modern lakes and streams themselves; while, if represented, these and the beds of drift would, over much the larger part of the country, leave exposed only the narrow isolated outcrops of the earlier formations which the learner finds it so difficult to correlate, in his mind's eye, and would show next to nothing of the general structure which it is the main purpose of such a chart to exhibit. Still, charts of the Quaternary continent would be exceedingly instructive, in their exhibition of the old lake-basins and drainage-lines of the continent. Besides the present Great Lakes, with their much greater extent and direct southern outlets, there were at least three great Quaternary lakes, in the Mississippi basin. One has its boundaries well marked by the Lower Silurian outlines of the Nashville basin of Middle Tennessee, its walls being mostly Subcarboniferous. Another occupied the western part of the Silurian basin of Central Kentucky and Southern Indiana, having similar walls on the west, (where its bordering sand-banks lie near the tops of the "Knobs"* fully 400 feet above the Ohio at Louisville,) and stretching far up the slopes of the Cincinnati anticlinal on the east—the boundaries in this direction being as yet unreported. A third occupied a large area on the flats of the Upper Silurian and Devonian areas of Northwestern Indiana;† and perhaps still others swept over the broad prairies of Illinois and the States further west.

Dana has long since called attention to the now-submerged old valley of the Hudson, as marked on the continental border, out to the true edge of the oceanic depression. The lines of soundings along the coast, kindly furnished to me by the officers of the Coast Survey, originally showed a slight bend opposite the mouth of Chesapeake Bay, probably indicating a corresponding notch in the bottom-slopes; but this was overlooked by both the engraver and the proof-reader. In the Gulf of Mexico, the angles of the soundings-lines point directly to Pensacola, the deepest harbor of the Gulf; and this line, continued, meets the Tallapoosa River at its abrupt angle near Montgomery. I have been informed (by Prof. Nicholson, of Knoxville, Tenn., I think) that a broad valley, with high terraces, but now deserted by the river, runs directly south from this angle of the Tallapoosa, as if on a direct course for Pensacola. During the Champlain period, when the streams of all this region were from 170 to 200 feet or more above their present level, this Tallapoosa river received a large share of the drainage of East Tennessee and Western North Carolina; and I have suspected that this old channel was the line of outflow of this great flood, direct to the deep water of the Gulf. The Gulf of Maine and the Gulf of St. Lawrence are well marked by the

* Borden, Geological Survey of Indiana for 1873, p. 181.
† Geology of Illinois, iv, 227.

fathom-lines.* The drift of icebergs, as marked by dots on the small corner-map, shows the source of the material of the "banks" of Newfoundland, and the area over which the growth of the continent is now most actively going forward. It is also evident that the shallowness of the Strait of Belle Isle, which prevents the passage of any but the smallest icebergs, is the principal means of preventing the filling up of the deep channel of the Gulf of St. Lawrence with the sediment now dropped on the "banks."

I shall be under deep obligations to all who will be so kind as to furnish exact data for corrections to be made in future editions of the chart.

ART. XXXVII.—*Observations upon the latest Planetoids;* by C. H. F. PETERS. [From a letter to one of the Editors, dated Litchfield Observatory of Hamilton College, Clinton, N. Y., Sept. 5, 1876.]

As the moonlight now for some days is interfering with observing the small planets, I communicate of the observations hitherto obtained the first and last positions of each, omitting for brevity's sake the intermediate ones. The dates of discovery and the names proposed of these new additions to the group are the following:

(165) *Loreley*, 10·7 magnitude, discovered Aug. 9.
(166) *Rhodope*, 11·2 magnitude, discovered Aug. 15.
(167) *Urda*, 12 magnitude, discovered Aug. 28.

1. Observations of *Loreley:*

1876.	Mean time.	α	δ	
	h m s	h m s	° ′ ″	
Aug. 9.	10 34 27	21 27 46·57	−10 0 10·7	(16 comp.)
Aug. 27.	10 26 49	21 13 2·52	−10 13 8·5	(10)

besides observations of Aug. 10, 11, 12, 13, 17, 20, 21, 23.

2. Observations of *Rhodope:*

1876.	Mean time.	α	δ	
	h m s	h m s	° ′ ″	
Aug. 16.	12 27 2	21 31 24·30	−19 15 16.1	(14)
Aug. 28.	11 33 39	21 21 55·06	−21 7 20·0	(10)

besides Aug. 17, 20, 21.

3. Observations of *Urda:*

1876.	Mean time.	α	δ	
	h m s	h m s	° ′ ″	
Aug. 28.	14 18 21	21 58 32·28	−11 33 41·4	(12)
Aug. 30.	13 35 16	21 57 1·33	−11 23 29·5	(12)

* On the map, by the mistake of the engraver, the 50-fathom line, along the west side of the Gulf of St. Lawrence, is made just like the 100-fathom line.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the Estimation of Nitrogen in Potable Waters.*—FRANKLAND, in a paper on the analysis of potable waters, gives the results of eight additional years of experience with the waters supplied to London. He says that the two chief objects to be kept in view are "the discovery of the evidence of *past* pollution by organic matter and the quantitative determination of *present* or actual organic impurity." With reference to the first point, he gives his opinion that the presence of nitrogen in the forms of nitrates, nitrites and ammonia in potable waters, in quantity above that which can be derived from rain, is reasonably safe and trustworthy evidence of the previous pollution of that water by animal matters. As to the second, he shows that, of the four processes proposed for determining organic constituents, known as the ignition, the permanganate, the albuminoid-ammonia and the combustion methods, the two first are quite useless; of the third he concludes from the extended experiments made by himself and others: 1st, that it affords no evidence whatever of the absolute quantity, either of organic matter or of organic nitrogen, present in potable water; 2d, that it does not indicate, even approximately, the relative quantities either of organic matter or of organic nitrogen in different samples of such water; 3d, that it affords no indication either of the presence or of the proportion of albuminoid as distinguished from other nitrogenous organic compounds; and 4th, that it is entirely useless therefore in the examination of waters for sanitary purposes. The combustion process, however, devised by himself nine years ago, he believes to be reliable. He claims for it: 1st, that it is the only method at present known which affords any trustworthy information respecting the organic matters present in potable waters; 2d, that it is the only method which even professes to determine organic carbon in such waters; 3d, that the determinations by it of organic carbon and nitrogen are fairly accurate, notwithstanding the very minute quantities of matters dealt with; and that the errors, even of a comparatively inexperienced analyst are far within the limits which would affect a verdict upon the quality of the water submitted to investigation; 4th, that it is the only process which discloses the proportion of nitrogen to carbon in the organic matter of waters, such information being often of prime importance in reference to the origin of the organic matter; and 5th, that since the modifications which have been made in the mode of evaporation the process can now be conducted in any laboratory and with a moderate expenditure of time and labor.—*J. Ch. Soc.*, clxii, 825, June, 1876.

G. F. B.

2. *On the Absorption of Nitrogen by Organic substances.*—BERTHELOT has found that pure nitrogen gas is absorbed by or-

ganic bodies at the ordinary temperature, under the influence of the silent electric discharge. Benzene, for example, absorbed, for every gram used, four or five cubic centimeters of nitrogen; the benzene being exposed either in vapor or in very thin layers of liquid. A condensed, polymerized compound resembling a resin, collected on the sides of the tube, which evolved ammonia when heated. Turpentine, marsh gas and acetylene act similarly. Filter paper slightly moistened, absorbs notable quantities of nitrogen, when thus treated, which is set free as ammonia on combustion with soda-lime. The same fact was observed with dextrin. Since neither nitrates or nitrites nor ammonia is produced, the author believes that a complex nitrogenous compound is formed by the direct union of the free nitrogen with the substance employed. He considered these facts of importance relative to the fixation of atmospheric nitrogen in nature.—*Bull. Soc. Ch.*, II, xxvi, 58, July, 1876. G. F. B.

3. *Action of the Copper-zinc Couple on Chlorates and Perchlorates.*—ECCLES, working under Thorpe's direction, finds that potassium chlorate is easily and completely reduced to chloride by the action upon its solution at the boiling temperature, of a properly made zinc-copper couple; so that an accurate quantitative method may be based on it. Potassium perchlorate, however, undergoes no change under these conditions. This fact the author has made excellent use of, to prove that the decomposition of the chlorate by heat takes place in two stages, in the first of which perchlorate is produced. The progress of the decomposition may also be accurately studied in this way. No perchlorate is formed, however, if manganese dioxide be added to the chlorate.—*J. Ch. Soc.*, clxii, 856, June, 1876. G. F. B.

4. *On a supposed shifting of Atoms.*—DEMOLE has examined critically the substance obtained by Baumstark by the action of an alcoholic solution of iodine upon ethylene, to which he assigned the formula C_4H_9IO, and which he supposed to be ethylidene-iod-ethylin. The improbability of the ethylene grouping being changed to that of ethylidene by this simple action, led Demole to prepare the ethylene compound synthetically with a view to compare its properties with those of the new body. For this purpose, mono-ethyl-glycol was prepared, and treated with phosphorus iodide. The reaction is:

$$\left(\left\{\begin{matrix} CH_2OH \\ CH_2OC_2H_5 \end{matrix}\right.\right)_3 + PI_3 = \left(\left\{\begin{matrix} CH_2I \\ CH_2OC_2H_5 \end{matrix}\right.\right)_3 + P(OH)_3.$$

The substance thus obtained was found to be identical in its properties with that obtained by Baumstark. His body is, therefore, ethylene-iod-ethylin. By the action of sodium-ethylate on it, acetal is produced.—*Ber. Berl. Chem. Ges.*, ix, 743, June, 1876. G. F. B.

5. *On Crystallized Glycerin.*—VAN HAMEL ROOS has examined a quantity of fifty-six pounds of crystallized glycerin. The crystals are monoclinic, perfectly colorless, and of a pure sweet taste.

Placed in ordinary good glycerin, they cause the formation in it of magnificent crystals. When melted at 60° F. the liquid has a specific gravity of 1·261. This cooled to 30° F. solidifies easily by the introduction of a small crystal of glycerin. At 24° F., the solidification is spontaneous after some time, though agitation seems to be indispensable. The melted glycerin is much less easily fermented, and hydrocyanic acid is without action upon it Since the crystallization of glycerin depends on its being pure and anhydrous, the formation of crystals is the best test of purity, and at the same time the best method of purification.—*J. Chem. Soc.*, clxi, 651, May, 1876. G. F. B.

6. *On the Lactic acid obtained from Inosite.*—Scheerer, the discoverer of inosite, mentions its breaking up by fermentation into lactic acid. Vohl, the discoverer of phaseomannite, which he subsequently proved to be identical with inosite, also proved the identity of the lactic acid from this substance, with the ordinary lactic acid of fermentation. This statement having been called in question by Hilger, Vohl fermented 250 grams inosite dissolved in two liters of water, by the aid of putrid cheese with the addition of chalk, at a temperature of 25° to 28° R. The thick mass of calcium lactate was treated with animal charcoal, boiled and filtered hot. On cooling, calcium lactate crystallized out and was purified by repeated crystallization. These crystals had 29·098 per cent crystal water; the salt of common lactic acid contains 29·221, that of sarcolactic acid 21·721. The zinc salt gave 18·104 per cent water, the quantities of the two salts respectively being 18·178 and 12·901. Moreover, the insolubility of the zinc salt showed it to be common lactate. Oxidation yielded acetic and formic but not a trace of malonic acid.—*Ber. Berl. Chem. Ges.*, ix, 984, July, 1876. G. F. B.

7. *Synthesis of Polybasic Acids by the action of Carbon dioxide on Salicylic acid.*—Ost finds that by passing a stream of dry carbon dioxide gas over basic sodium salicylate, the gas is absorbed and an acid formed having the formula $C_6\begin{matrix}H_3\,COOH\\OH\,COOH\end{matrix}$ which he calls ortho-phenol-dicarbonic acid. A similar tricarbonic acid is also formed in this way.—*J. pr. Ch.*, II, xiv, 93, July, 1876. G. F. B.

8. *Freezing of Colloids.*—Prof. Guthrie described to the London Physical Society some experiments on the freezing of aqueous solutions of colloid substances, which he has been studying in connection with his recent investigation on cryohydrates, etc. If a solution of sugar be gradually cooled, the temperature at which ice separates out is always below 0° C. and the extent below increases with the amount of sugar in solution; but he finds that in a solution of gum having exactly the same chemical formula, the ice always separates at 0° C. whatever be the amount of gum present. Thus while every crystalline substance forms a freezing mixture when mixed with ice or snow, colloids are incapable of doing so. The gum and the water do not recognize each other;

and similar results were obtained in the case of gelatine and albumen. These facts are strictly in accordance with the results of Prof. Graham's classical researches. It also follows that, when heated, similar effects are observed, and Prof. Guthrie has found that solutions of gum in varying proportions always boil at 100° C. —*Nature*, xiv, 264. E. C. P.

9. *Explosion of Fire Damp.*—M. MALLARD has measured the velocity of inflammation of various mixtures of fire-damp and air. Various mixtures were set in motion with different velocities, and that velocity at which the zone of combustion remained stationary measured the velocity sought. The highest velocity of inflammation was 560 meters per second, and it occurred in a mixture of 0·108 vol. of fire-damp in one volume of the mixture. On increasing or diminishing the proportion of fire-damp, the velocity in question diminished very rapidly, becoming *nil* with a proportion of ·077 vol. on the one hand, and 0·165 vol. on the other, below which the mixtures are neither explosive or inflammable. It is notable that a variation of even 0·01 in the proportion of fire-damp is sufficient to convert an absolutely indifferent mixture into a highly dangerous one.—*Naturforscher*, Feb., 1876; *Nature*, xiv, 202. E. C. P.

10. *Velocity of Electricity.*—Dr. W. SIEMENS has measured the velocity of propagation of electricity in land telegraph lines by the following apparatus: two condensers have their outer terminals connected by a metallic wire. Their inner terminals are attached to two points placed near a registering cylinder connected with the earth. The connection for one point is a short wire, and for the other a telegraph line. The two condensers are discharged simultaneously by connecting their outer terminals with the earth when the cylinder gives the interval which has elapsed between the two sparks. Instead of the telegraph line a rubber tube thirty meters long and twenty millimeters in diameter and filled with sulphate of zinc was first used. The interval between the discharges was inappreciable, and certainly did not exceed five millionths of a second. With a line 25·36 kms. long, the retardation was 125-millionths; with another of 23·37 kms. the retardation was 101-millionths, and with a third of 7·35 kms., thirty millionths. These times are nearly proportional to the length of the lines. The capacity of the two shorter lines was ·15 and ·063 microfarads and their resistance eight Siemens per kilometer. The retardation by comparison with that of condensers of known capacity ought to be only two millionths of a second. Thus the retardation observed is much greater than that required to charge the cable and is not proportional to the square of the length. M. Siemens concluded from this that the electricity has really a velocity of propagation. It must be remarked, however, that the insulation of the lines was not observed, and that slight leakages through the supports would have the effect of increasing the time necessary to charge the line, and of rendering it more nearly proportional to the length.—*Pogg. Ann.*, clvii, 309; *Journ. de Phys.*, v, 226.

E. C. P.

11. *Polarization Currents.*—MM. SCHILLER AND CALLEY describe an experiment showing the electro-dynamic action of a polarization current. It is well known that water cannot be decomposed by a single Daniell's cell; but if a voltameter and galvanometer are inserted in the circuit of such a cell the needle deviates at the moment of making or breaking the circuit. These well known facts have led some persons to compare a voltameter to a condenser of great capacity. The question is to determine whether the liquid conductor can exercise an electro-dynamic action while the electrodes are being charged. *A priori*, this is not self-evident, but is established by the following experiment. In a Wiedemann's galvanometer, one of the bobbins was replaced by a coil formed of a rubber tube filled with water free from air and slightly acidulated. The coil consisted of thirteen turns six centimeters in diameter. The resistance was 1600 Siemens. The two bobbins (one metallic, the other liquid) were so placed that the current of four Daniell cells traversing both at the same time and decomposing water did not deviate the needle. The four cells were then replaced by a single one. On closing the circuit no deviation was observed but on removing the metallic bobbin a deflection was obtained amounting in the first swing to twenty divisions.—*Journ. de Phys.*, v, 261. E. C. P.

12. *Magnetic Induction.*—M. CHWOLSON presents a second valuable memoir on the mechanism of magnetic induction, which process he seeks to explain by the supposed existence of molecular magnets which are turned by the external force in one direction. In his former paper he dealt with the case of temporary induction in soft iron; he here treats of magnetic induction in steel. The paper is in five chapters; in the first are summarized the results obtained by previous observers, those of Jamin being given with special fulness. In the second the author describes his experiments, which require a modification of Jamin's theory. Of Jamin's two laws relating to the action of positive and negative currents or permanently magnetized bars, Mr. Chwolson finds the first absolutely correct; the second incorrect. Jamin's mistake he considers to be in the supposition that the negative current acts only on the surface layers, leaving those below untouched; it is shown on the contrary, that the least negative current acts on all the layers and diminishes their intensity. Then he gives a mathematical theory of induction in steel; supposed the first attempt of the kind (if Maxwell's but partly successful one be excepted). In the fourth chapter he explains, on the basis of theory, the various experimental results got by different observers; and in the fifth shows how certain results that might, *à priori*, be foreseen from the theory, have been verified.—*Pogg. Ann. Erganz.*, vii, 4; *Nature*, xiv, 202. E. C. P.

13. *Constants of Nature.* Parts II and III, and first supplement to Part I. Compiled by F. W. CLARK, Prof. of Chem. Univ. Cincinnati. 1876. Washington. Smithsonian Misc. Collections, Nos. 276, 287, 288. Part II of Prof. Clark's thorough and very

useful work, includes a table of specific heats for solids and liquids; Part III, tables of expansion by heat for solids and liquids; and the Supplement to Part I, specific gravities, boiling points, and melting points.

II. Geology and Mineralogy.

1. *On the Age of the Vertebrate Fauna of the Eocene of New Mexico;* by Prof. Cope. (Proc. Acad. Nat. Sci. Philad. for April, 1876.)—Comparison with the established scale of geological horizons of Europe has established the fact that the beds in question belong to the Eocene category, as I have already shown* to be true of the longer-known Bridger beds of Wyoming. It remains to collate them with the numerous subdivisions of that period. The differences between the Wahsatch and Bridger faunæ have been in part pointed out in my Report on the Vertebrate Fossils of New Mexico,† 1874, and may be more fully stated as follows:

(1) Divisions found in the Wahsatch beds not yet reported from the Bridger beds. Aves, genus *Diatryma* (allied to *Gastornis*); mammalia, *Tæniodonta; Phenacodus; Coryphodon;*‡ *Meniscotherium;* most species of *Hyracotherium.*

(2) Divisions found in the Bridger beds not yet found in the Wahsatch: fishes, *Amiidæ;* reptiles, *Ophidia; Anostira;* mammals, *Mesonychiidæ; Tillodontia; Achænodon; Dinocerata; Palæosyops;* most species of *Hyrachyus.*

The Wahsatch horizon of Wyoming has not yielded so many species of vertebrata as those of New Mexico,§ but the close resemblance of the two faunæ may be observed in the following list of forms which I obtained at several localities: Fishes, *Siluroids;* mammals, *Hyracotherium,* two species; *Phenacodus; Coryphodon,* two to three species. As is well known, the Wahsatch beds underlie those of the Bridger group, and we therefore look for their European equivalent in the lower part of the series. It has been already pointed out‖ that the absence of *Hyopotamus* and *Anoplotherium,* and allied genera, from the Bridger horizon, precludes an identification with the Upper Eocene of Europe. The comparison of the Wahsatch fauna with that of the lowest of the three divisions into which Professor Gervais has arranged the European Eocene, shows a remarkably close correspondence. This epoch, the Suessonien of D'Orbigny (Orthrocene, Gervais), includes the marls of Rilly and lignites of Soissons, the Thanet sands, London clays, etc. Fossils from these beds appear to have been no better preserved than those of the Wahsatch beds of the Rocky

* Proceedings American Philosophical Society, 1872, February and July.

† Annual Report of Chief of Engineers, p. 592.

‡ The species described by me as *Bathmodon* constitute a section of this genus, characterized by the absence of tubercle or ridge between the inner cusps of the last lower molar. I do not maintain this section as a distinct genus.

§ See Report of the U. S. Geol. Surv. Terrs., 4to, ii, pp. 33–39.

‖ Ann. Report U. S. Geol. Surv. Terrs., 1873 (1874).

Mountains, yet some of the genera are identical, and others closely correspondent, as follows:—

Wahsatch.	Suessonien.
Ambloctonus.	Palæonyctis.
Hyracotherium.	Hyracotherium.
Coryphodon.	Coryphodon.
Diatryma.	Gastornis.
Lepidosteus.	Lepidosteus.

As a point of difference between the beds, may be mentioned the absence of the *Tæniodonta* from the Suessonian, a sub-order not yet known out of North America.

The Wahsatch formation includes the Green River Beds of Hayden, a name which I formerly used for the entire series. It, however, applies properly to the fish shales of Green River, containing *Asineops*, *Clupea*, *Osteoglossum*, etc., which are probably local in their character.

The Bridger formation will then represent on the American continent, more nearly than any other, the Middle Eocene or Parisien of Cuvier, Brongniart, and Renevier.

The teeth of sharks described in the reports quoted are of uncertain origin. They are associated with oyster shells, and both have the appearance of having been transported; nevertheless, some of the mammalian teeth found associated with them have a similarly rolled appearance. It therefore remains uncertain whether the ocean had for a limited time access to the Eocene lake, or whether the shark's teeth and *Ostreæ* were derived from the Cretaceous beds which formed its shores. Similar, and in one instance the same species of sharks were found in both formations, the division of the Cretaceous being No. 3 and 4 of Hayden.*

In conclusion, the classification of the North American Eocene may be represented as follows:—

Formation.	Equivalent.	Locality.	Characteristic Fossils.
Bridger Form.	Middle Eocene.	S. W. Wyoming.	Palæosyops. Tillodontia. Dinocerata.
Wahsatch Form.	Lower Eocene.	N. E. New Mexico, S. W. Wyoming.	Coryphodon. Tæniodonta. Phenacodus. Diatryma.

2. *Note upon the Geological position of the Serpentine Limestone of Northern New York, and an inquiry regarding the relations of this Limestone to the Eozoon Limestones of Canada*, by Prof. JAMES HALL.—(The following is an abstract of this paper read before the American Association at Buffalo.) On the geological map of the State of New York now before you, you will observe a large area in the northern part of the State, colored of a light reddish tint. The formations occupying this space were originally termed Primary, and more recently Laurentian. They constitute

* The same state of things exists in the siderolitic deposits of the Canton of Vaud, Switzerland. Mingled with the mammalian remains are teeth of sharks, of which M. La Harpe remarks that their appearance does not warrant the belief that they have been transported, or are not indigenous to the Eocene fauna.

the oldest rock formations of the State, as well as of the eastern part of the continent, although we well know that they represent several geological periods.

The counties of Essex, Warren and Hamilton are almost entirely occupied by rocks of the Laurentian system proper, while a large part of Clinton, Franklin, and a considerable portion of Saratoga and Herkimer, are occupied by the same geological formations.

The eastern part of Saratoga and Warren and the shore of Lake Champlain, in Essex and Clinton counties, are marked by the presence of the Postdam and Calciferous sandstone and the Chazy and Trenton Limestones, one or all of them; and the northern part of Clinton presents a broad outlying area of the Potsdam sandstone, which stretches westward across Franklin and St. Lawrence counties and thence into Canada.

The rocks of the lower division of the Laurentians consist of black hornblendic, gray garnetiferous and coarse feldspathic and quartzose gneisses, with extensive beds of magnetic iron ore. These are succeeded by massive beds of labradorite rock—the hypersthene rock of Emmons and other granite rocks. This part of the formation is marked by extensive beds of titaniferous iron ore. The succession is however unconformable, and the interval between the two series of rocks is not determined, nor does it appear to be determinable from examinations thus far made within the State of New York.

Associated with these gneissic and labradorite formations are one or more bands of crystalline limestone—the primary limestone of Emmons. This limestone is usually and perhaps always permeated by serpentine in grains, bands, or what sometimes appear as concretionary or aggregated masses of that mineral. This limestone in the eastern counties of northern New York has been considered a part of the Laurentian series, and is thus treated I believe by all geologists.

Having, in 1866, been occupied in some critical examinations of the region in the neighborhood of Port Henry and Westport, I became satisfied that the limestone of that neighborhood did not form a part of the lower Laurentian series of strata, but unconformably overlaid the upturned edges of the gneissic beds of that portion of the system. Neither does it conform to the upper or labradorite portion of the system. Having had occasion to pass over the same region almost annually since that period I have been confirmed in my previous observations.

The limestone in the neighborhood of Port Henry is usually a heavy bedded crystalline limestone with grains and blotches, and more rarely layers of serpentine. Sometimes it is conspicuously brecciated, and contains fragments of gneissoid rock which seem to have been derived from the strata below, upon which the rock lies unconformably. The same belt of limestone occurs at intervals, flanking the Laurentian rocks to the southward, and is conspicuously present in the town of Minerva, and it is apparently the same belt which is known in Warren county. From the latter ocality it has been reported as containing Eozoon.

The limestones of St. Lawrence and Lewis counties are usually more coarsely crystalline, with larger bands of serpentine, and with a somewhat different association of minerals, from those of the eastern counties, and the identity of the two is not proven. Nevertheless these limestones, last referred to, with their associated beds of granitic and other rocks, with specular iron-ore, are not of true Laurentian age, and their relations to the latter are at present not well determined, except that they are of more recent date in the geological series.

The simple point which I wish to demonstrate is that this limestone of Essex and adjacent counties does not belong to the Laurentian system, either lower or upper. That it is a formation deposited along the flanks of, and within the Laurentian area, at a period subsequent to the deposition, metamorphism and disturbance of the rocks of authentic Laurentian age, and that it apparently holds a place in the series between the Laurentian and Potsdam periods, but whether of Huronian age or otherwise I do not pretend to say, and it may even prove of later date than this.

With these facts before us it becomes a matter worthy of inquiry, whether the Eozoon limestones of Canada, which are associated with Laurentian rocks and have been referred to that age, are really Laurentian, or hold the place and position of those of Northern New York.

NOTE.—Since preparing the statement giving views here presented, I have been informed that Mr. Vennor, of the Canadian Geological Survey, in a paper read before the Natural History Society of Montreal, has expressed an opinion that the Eozoon limestones of Canada are not of Laurentian age. Not having seen the communication I am only able, at the present time to add this note, but with the permission of the Association will make a more extended reference in the final publication.—*Buffalo Courier*, Aug. 25.

3. *On the Geology of the Southern Counties of New York and adjacent parts of Pennsylvania, especially with reference to the Age and Structure of the Catskill Mountain Range;* by JAMES HALL (Proc. Amer. Assoc., 1875, p. 80).—The object of this paper is mainly to state and illustrate the results of four years of labor, chiefly in the southern counties of New York and the adjacent northern portions of Pennsylvania, by Mr. Andrew Sherwood, assisted by Mr. Clark Sherwood, under my direction.

The question has been raised regarding the existence of the Old Red Sandstone, or Catskill group, within the limits of New York, although a considerable area had been thus colored on the original geological map of the State.

The assertion of the non-existence of this formation in the State had induced me many years since to review some portions of my work of 1844, and, while in the main features it was found correct, it became evident that something farther was needed in the elucidation of the structure of the Catskill region. In fact, it became evident that one could travel from Schoharie county to the Penn-

sylvania line, on rocks of the Chemung group, without touching or seeing the Old Red Sandstone. And from this circumstance arose the statement of the absence of this formation from the State of New York. It became a very different matter, however, when one crossed the same region of country from east to west.

After several visits to this region, and notably one in 1857, with Sir William E. Logan and Andrew C. Ramsay, (the latter now Director of the British Geological Survey,) the question of the geological age of this great accumulation of strata assumed a still more important aspect; and the question has never been lost sight of; though for many years it has been quite impossible for me to undertake the investigation.

Referring to the Geological Map of New York, of 1843, a large area is colored as the Catskill Group without indication of geological structure. A similar feature was seen in northern New York; where the limits of the Laurentian system had barely been determined. Geological surveys have been carried on with too much haste, and under the pressure of necessity, from limited time; therefore it was, that we were compelled to content ourselves with determining the limits of formations, and not the structure, which required long and careful investigation.

In 1870, when for the first time I was able to give attention to this part of the country, there was no definite knowledge of the region; the record of the Geological Map had been controverted; and the non-existence of the Catskill or Old Red Sandstone, within the State of New York, was the prevalent opinion.

Mr. Sherwood was employed to begin his investigations in the spring of 1871, and has continued till the close of 1874. To accomplish the work represented on the map before you has, therefore, cost the labor of two men for four years. It now presents the aspect of a piece of work completed, except that from the erroneous maps of the State we are unable to give more than the approximate limits of the outcrops.

The work has not only accomplished what was undertaken, but has proved conclusively the existence (first suspected in 1857) of higher formations, lying upon the red Catskill rocks.

The entire region, from the base of the Catskill range to the western limits of the red rocks, in Chenango county, presents a series of nearly parallel anticlinal and synclinal folds; and the same structure is continued to the western limit of the State, although the red rocks may not appear within the State; and the formation probably thins out entirely, before reaching the western boundary of New York and Pennsylvania.

The topographical sketch presents a view of the Catskill range from the east side of the Hudson river, opposite to Catskill, looking over the shales of the Hudson River Group; the general dip of the rocks is perceptible in their inclination to the southward. In a cross section of this range, the dip of the strata to the northwest and southeast is shown, forming synclinal and anticlinal folds, of which five synclinals and six anticlinals are included in the extent given.

The expression of the map in its coloring shows the direction and extent of certain belts of red rock, which in some part of their extent are crowned by gray sandstone and conglomerate, referred to the Vespertine and Umbral formations of Professor Rogers, and regarded as belonging to the Carboniferous age.

These belts are the synclinal axes, which sometimes embrace the higher rocks within their folds, and have, in some localities, been so far eroded as to leave only a narrow belt of red rock; and even this has been in many places removed, and the erosion has penetrated deeply into the rocks of the Chemung Group.

Going to the south of the State line, these synclinals carry outliers of the Coal-measure, greater or less in extent, as shown by the map. In the Catskill region the general direction of these synclinals and adjacent anticlinals is from southwest to northeast; but farther to the westward they gradually decline in abruptness, and assume a more nearly east and west direction.

The anticlinals are everywhere valleys, along which the streams flow and the main roads of the country are made; the road from Kingston to Delhi being the principal exception. In going to the east or west of these we ascend over the rough and broken country formed by the outcropping of the Red Sandstone and Conglomerate. Owing to the great difficulty of crossing this country, we have long remained ignorant of its geological structure. The synclinals everywhere present high and broken ridges, and more especially so when the Vespertine and Umbral rocks form the terminal mass.

It is true that the Delaware and Susquehanna rivers both flow across or through these synclinals, in channels made by deep erosion.

The parallel ridges of the high country culminate in the Catskill mountains, where we have an elevation of nearly 4,000 feet above tide-water. The cause of this greater elevation is shown to be due to the convergence of three synclinals, which, presenting such a mass of material to the eroding forces, has prevented the anticlinals from being excavated below the red rocks of the Catskill formation. To this condition we are indebted for the higher portions of the range, which present, in a topographical aspect, only an irregularly scattered mass of mountain elevations.

The section exhibited, crossing the Catskill range from Schenevus to Glasco, is on a line south of the culminating ridges, and therefore does not present the highest points of the range. The lower rocks of the section are of the Chemung Group; but the relations of all these are shown on the smaller section from the Mohawk to Carbondale.

The lower beds shown, of Portage and Chemung, have a thickness of more than 2,000 feet; while the rocks above, which may be referred to the Catskill, are about 3,000 feet thick, and the higher beds, of Vespertine, extending to the summit of Round-Top, may be reckoned at about 800 feet.*

* That the entire mountain elevation above tide-water does not exceed 4,000 feet, is due to the dip of the strata, which makes the elevation so much less than the thickness.

The passage from the red rocks to the gray sandstone and conglomerate is gradual, with alternations of red and gray rocks, and does not afford any strong line of demarcation.

The remains of *Holoptychius*, in the form of bony plates, fragments of bone, etc., extend through a thickness of more than two hundred feet.

In its western extension, the red rock, with its alternations of green and mottled beds, shows a gradual thinning, and finally seems to be lost entirely.

One of the greatest difficulties met with in this investigation, has been the occurrence of red and greenish shales in the Chemung and Portage beds; and the finding of gray beds with Chemung fossils at an elevation of at least one hundred and fifty feet above the base of the red rocks, which had always been referred to the Catskill formation.

We have finally, however, ascertained, as I believe, the limits of the formation, and though not always in strong contrast with the rocks below, we have been guided both by physical and biological conditions.

In the interval between well-marked Chemung and typical Catskill, there are beds of intermediate character, and we sometimes find a few fossils of the lower rocks. The same means of distinction do not occur in all localities. In some places the indications of the Catskill are in the red shales and diagonally laminated sandstones. In other places we find a mass of vegetation, with or without the presence of the large Lamellibranch known as *Cypricardites Catskillensis.* The occurrence of this fossil may, in my opinion, be relied on as characterizing the base of the Catskill formation, while the *Holoptychius* marks the beds above, but still is not known above the middle of the formation.

Another question, involved in this investigation, has been the determinations of the relations of these red rocks to the superior sandstones and conglomerates, which in eastern New York and Pennsylvania are known as Vespertine and Umbral. The question also as to the character of these latter rocks in their western extension, is one of great interest, and whether the Waverly sandstones of Ohio may or may not be a continuation of the former.

In some localities in the border counties of western Pennsylvania, the rocks regarded as the Waverly Group of Ohio, rest directly upon the Chemung; and the fossils of the Chemung pass into the higher beds and mingle with other species regarded as Carboniferous forms.

Indeed, from the little I have seen, I should say, that in the region referred to, there are more species of fossils passing from the Upper Chemung into the Waverly formation, than there are species passing from the lower to the upper division of the Chemung group proper.

The question is of great interest in view of the supposed horizon of Carboniferous forms; but if we are able to substantiate the foregoing proposition, I think it will be shown that the Chemung

fauna continued its existence till after the appearance of Carboniferous forms, and that the two faunas, if they can be properly so regarded, lived in the same sea and at the same epoch; and the question of the limits between Devonian and Carboniferous formations, is likely, at least for some time, to remain undetermined in some parts of the country.

The work is still unfinished in the western part of the State; but we have indications of what we may expect to find on farther investigation.—*Proc. Amer. Assoc.*, Detroit, 1875, p. 80.

4. *On the Erosion of Rocks;* by E. B. ANDREWS. (Communication to the Editors, dated Lancaster, Ohio, Sept., 1876.)—Attention having been recently called to the subject of erosion by the excellent papers of Mr. G. K. Gilbert, I beg a little space to present one feature of the weathering of rocks, which may be worthy of more consideration than it has received.

In some counties in Ohio, where the Waverly sandstone assumes a coarse semi-conglomeratic character, and in our Coal-measures where the sand rock is coarse and massive, we find many narrow valleys bordered by high cliffs, from fifty to two hundred feet high. These cliffs often overhang their bases forming recesses of from thirty to one hundred and fifty feet in depth from a vertical line dropped from the top. These rock-walled valleys when followed up are often found to terminate in semi-circular cliffs over which the little streams fall in pretty cascades. Behind the falls we find large semi-circular or crescent-shaped caverns, forming recesses sometimes large enough to hold regiments of men. The streams are generally very small and often become dry in the summer. They have worn for themselves only slight channels in the top rock,—the rock-roof of the cavern—but the point where the water strikes below is too far away from the side walls of the cavern to admit of any direct erosion, or of any mechanical undermining of the cliff. Ordinarily the whole range of the cavern wall is dry. But not so in time of freshet. Then the water comes down with great force of concussion, and the cavern becomes a "cave of the winds." The spray is driven into the inmost recesses and the moisture with the help of frost disintegrates the rocks. This spray from muddy waters leaves a coating of mud upon the walls of the cavern. Thus spray becomes the agent of undermining the cliff, just as the coal-miner makes his "bearing-in" in the lower part of the coal seam. In time, the projecting table-rocks fall and the valley is practically formed. In this way an enormous amount of valley erosion has been produced in sandstone regions.* A fine illustration of valley-making by means of a spray-formed cavern may be seen near the "Ash Cave," in the western part of Hocking County, Ohio. The Ash Cave is itself only a remnant of a spray-cavern. The overhanging cliff formed a dry and desirable shelter, and the recess was long

* The erosion at the Falls of Niagara, by spray driven by wind against the shale, is referred to by Lyell, in his account of the region given in his "Travels in North America," page 26, and also by Prof. James Hall in his New York Geological Report.

used by Indians, who have left upon its floor a large accumulation of the ashes of their fires,—a pile 100 feet long by perhaps 30 feet wide, and two and a half feet deep,—in which I have found buried human bones, seeds, and many Indian relics. The water-fall, with its semi-circular cavern, is a hundred rods above the Ash Cave. A similar large spray cavern is found on a small tributary of Salt Creek, a few miles below Jackson, in Jackson County. Here the rock is a Coal-measure conglomerate. I have seen hundreds of these caverns in coarse heavy-bedded sandrocks of the West.

It may be well to add to the foregoing statement the fact that there are, in the Waverly sandstone region, numberless valleys with terminal circular arched cliffs, which in the retrocession of the falls have been carried so far back toward the top or center of the dividing ridges as to leave for themselves drainage areas quite too small to afford water enough to continue the work of cañon-making. The streams, being only small affluents of the larger ones, and often not more than half a mile long, were at first large enough, when in freshet, to make the spray caverns and to remove the waste at the foot of the terminal cliffs. But now, with drainage area above the falls reduced to almost nothing, the water, even in its highest stage, is too feeble a porter to carry away the waste, and the heads of the cañons are slowly filling up from local disintegration, etc. The famous Rock House, in Hocking County—pictured in Ohio Geol. Report for 1870, p. 83—is an illustration of cañon-making in its last stages. The little stream, which has worked out the cañon, is probably not more than half a mile long from head to outlet, and of this length three-quarters are below the falls. The terminal cliff is 115 feet high. This cliff is near the summit of a hill, and the drainage of very few acres forms the insignificant brooklet that trickles over the edge and down the face of the rock. The whole length of the top edge of the cliff from side to side of the chasm is probably not less than 500 feet. The streamlet which, when I saw it, a child might almost divert from its course by a shingle, has changed its place from time to time, and so has operated along the whole face of the cliff. At the point back of the spot where the waters, when in freshet, must now strike the bottom is a small recess, formed by the weathering action of the spray. A small channel is kept open below the falls, but the stream is able now to carry away only a small part of the waste of the cliff and the wash of the soil above the cliff, and the work of filling up has begun. The Rock House, proper, is a magnificent corridor high up in the cliff, formed by the action of the little stream passing down a crack parallel to the face of the rock and finding outlets in transverse cracks.

5. *Report on the Geology of the Eastern portion of the Uinta Mountains, and a region of country adjacent thereto;* by J. W. Powell. 218 pp. 4to., with plates and sections, and also a folio atlas. Washington, 1876.—Major Powell, in this sequel to his Report on the Colorado region published in 1875, embraces, be-

sides the results of his study of the Uinta Mountains, a general consideration of the wide range of facts he has observed in the West. He gives, in systematic form, the views he has arrived at with regard to the nature of the mountain structures of the region, and the system in the faults, folds, and displacements of the rocks; also detailed sections of the series of sedimentary strata involved in the displacements, from the lowest rocks to the top of the Tertiary, and the distribution of these rocks in the Uinta Mountains; finally, he treats of the special structure of these mountains, and of the methods and results of their degradation. The subject of displacements is admirably illustrated by his plates, two of which are stereographic; and, owing to the bare condition of the surface, the facts have been made out with an exactness and amount of detail impossible in regions of soil and forests. An excellent feature of the work is the natural scale of all its sections, in place of the usual exaggerations. The views are partly those adopted by Mr. Gilbert. We propose to cite at length from the volume in another number of this Journal. The Report also contains a Paleontological Report by Prof. C. A. White, treating of Carboniferous, Jurassic, Cretaceous and Tertiary Invertebrate fossils, some of them new species.

6. *On a Gigantic Bird from the Eocene of New Mexico*, by Prof. COPE. (Proc. Acad. N. S. Philad., Feb., 1876.)—Prof. Cope exhibited a tarsometatarsus of a bird, discovered by himself during the explorations in New Mexico conducted by Lieut. G. M. Wheeler, U. S. A. The characters of its proximal extremity resemble in many points those of the order *Cursores* (represented by the *Struthionidæ* and *Dinornis*), while those of the distal end are, in the middle and inner trochleæ, like those of the *Gastornis* of the Paris Basin. Its size indicates a species with feet twice the bulk of those of the ostrich. The discovery introduces this group of birds to the known faunæ of North America recent and extinct, and demonstrates that this continent has not been destitute of the gigantic forms of birds, heretofore chiefly found in the Southern Hemisphere faunæ. The description is as follows:

The hypotarsus is moderately prominent, with a broad truncate face, and does not inclose the ligamentous groove of its inner side. Its superior angle is broken away in the specimen. The two foramina which pierce the shaft just below the head, are well separated from each other both on the posterior and anterior faces, marking nearly equal thirds of the transverse diameter of the bone. The cotyloid cavities for the tibio-tarsus are bounded by an elevated margin, and are separated medially by a single low oblique ridge. The groove of the posterior face is particularly wide, and the inner part of the shaft is thinned, while the outer border is broadly convex. The proximal part of the inner border (as far as it is preserved) is marked with a flat surface which is roughened with ridges, which is perhaps the sutural articulation of the proximal end of the metatarsus of the hallux. No such surface exists on the corresponding bone of the ostrich or emeu. Only two of the

free distal phalangeal extremities are preserved. The shaft is broken, showing that its interior is filled with cancellous tissue. The free extremities are remarkable for the great inferior extent of the articular trochlear face. The median is strongly grooved with an obtuse excavation, and the lateral or bordering ridges are equal and rounded. The groove is continuous with the superior surface, but not with the inferior. There the convergent lateral ridges inclosing the open groove, terminate in an abrupt elevation above the adjacent surface of the shaft. The sides at this point are concave. The inner free condyle has an oblique articular face, the external ridge dropping away internally as in many birds, and produced beyond the inner ridge, distally. The articular face becomes then a part of a spiral, and is little grooved above, but strongly grooved medially. The vertical diameters of the sides differ, the inner being much greater, and both are concave. A strong foramen pierces the shaft just within the point of junction of the inner and medial free extremities.

Measurements.		m.
Transverse diameter of proximal end of tarsometatarsus		·100
Antero-posterior do. (partly inferential)		·070
Interval between penetrating foramina on anterior face shaft		·017
Median distal condyle	Long diameter	·050
	Vertical diameter	·048
	Transverse diameter	·040
Internal distal condyle	Long diameter	·037
	Vertical diameter	·040
	Transverse diameter	·031

The large size and wide separation of the penetrating foramina, and the thin internal edge with suturul articular facet, distinguish this form as distinct from any of the genera of Struthionidæ and Dinornithidæ. It is therefore named *Diatryma gigantea.*

7. *Fifth Annual Report of the Geological Survey of Indiana made during the year* 1873; by E. T. Cox, State Geologist. 494 pp. 8vo, with maps.—This volume contains a general report by Professor Cox; a report on Clarke and Floyd counties, by W. W. Borden; on Warren, Lawrence, Knox, and Gibson counties, by Mr. John Collett; and observations in DeKalb and other counties, by G. M. Levette.

Footprints of Labyrinthodont character, found by Mr. Collett near the base of the Coal Measures in Warren county, are described and figured; they are 1¼ to 1½ inches long, and 1 to 1¼ broad, all 5-toed, and the stride is three inches. The species is named by Prof. Cox *Collettosaurus Indianensis.*

A *tripoli*, from "pockets" in the cherty limestone above Coal K, in Dubois county consists, according to Dr. J. Gardner, almost wholly of spicules of sponges; and in one cherty nodule from the same vicinity, there was, in a cavity near its center, a slight network of the glassy filaments of the sponge, about which concretion took place, indicating, as stated by Dr. Gardner, that the hornstone nodules found in the cherty beds correspond each to a fossil sponge.

Several *terraces* exist on the border of Lake Michigan, near Michigan City, the highest of which—the fifth—is elevated 225 feet above the lake. The fourth is 95 feet above the same level, and contains much coarse gravel.

8. *Fossil Plants of the Coal-measures of Terrera, in the Atacama district, Chili.* (Bull. Soc. Geol. de France, III, iii, 572, 1876.)—The plants are Jurassic, of the Lower Lias or Rhætic beds, and included *Jeanpaulia Münsteriana* Presl., *Angiopteridium Münsteri* Gœpp., a *Pecopteris* (*P. Fuchsi*), near *P. Gœppertiana.*

III. Botany and Zoology.

1. *Sensitive Stigmas as an aid to cross fertilization of Flowers;* by Prof. W. J. Beal, (Proc. Amer. Assoc., Buffalo.)—The flowers of *Martynia proboscidia*, a plant sometimes raised in our gardens for pickles, has flowers drooping at an angle of about forty-five degrees. At the opening on the upper side are two flat stigmas, curved back away from each other, exposing the surface which is sensitive to pollen. Farther on are the four anthers, side by side, with their cells placed end to end. The opening is just large enough to take in the humble bee, or the common hive bee will do as well.

I have been carefully watching the Martynia plants for several weeks, since they have been in flower, every day and at nearly all hours and sometimes several times a day. I have the plants in four places, two of which are beds about four feet by ten. They are among other beds of flowering plants which are freely visited by various kinds of insects. I felt quite sure that the humble bee transferred pollen on his back, because I found the stigmas covered with pollen and closed before night each day. I could not contrive how else the pollen could be transferred. I began to fear I should have to give it up. But, one morning about nine o'clock, I saw a single humble bee pass from flower to flower on nearly every specimen on one patch of plants. The visit lasted only a few moments. All parts are quite sticky with glutinous hairs which seem to annoy the bees very much. I have never seen but one bee on the flowers of Martynia; she alighted on the spotted, showy part of the corolla, and crawled, first hitting the stigmas.

One of the most interesting points is now to be explained. The stigmas are sensitive to the touch, and close up in five to ten seconds; often before the insect is ready to back out of the flower. If they are not quite closed at that time, the bee shuts them by pushing her back against the back of one of the stigmas. The lower lobe of the flat stigma next to the bee's back is the larger. No pollen can be left as the insect retreats. A cross of pollen is usually certain. If not very freely dusted with pollen the stigmas open again in about fifteen minutes; if well dusted I have known them to remain closed afterward.

The single flat stigma of the iris, one on each of three sides of the flower, has often been shown to be sure of cross-fertilization, if

fertilized at all. Some years ago I examined hundreds of specimens as they were fertilized by bees. The stigma closes up after it is covered with pollen. It is sensitive to the touch; perhaps only slowly, but I think it moves back in a few seconds. I have examined no specimens lately with special reference to this point. The stigmas of *Mimulus ringens* are curved out like those of the Martynia, and project beyond the anthers. I have seen small native Hymenoptera visit this plant, always crawling in with the back down, although Mühler says in personate flowers the bees always get their backs up as they pass in. The stigmas of this *Mimulus* are slowly sensitive, closing in a few moments after they are touched or well supplied with pollen. The stigmas of the *Mimulus luteus* and *Mimulus moschatus*, and likely other species, close very quickly after being touched. *Tecoma radicans* and *Tecoma grandiflora* and probably other species, are very much like Martynia in the peculiarities mentioned. I have not lately had the opportunity of examining the flowers of the Bigonia or Catalpa but I shall expect to find them cross-fertilized in the same way as Tecomia aided by sensitive stigmas. *Utricularia vulgaris*, one of our larger common bladderworts, has a yellow irregular flower which considerably resembles that of the snap-dragon. The stigmas act much as in Martynia. The lower lip of the stigma is much the larger and when touched bends up close against the upper lip of the corolla just under an arch-like projection. The other nice adaptions for securing cross-fertilization are rather complicated and need not be given at this time.

Pinguicula is quite similar in structure to the Utricularia and is likely sensitive in its stigmas, and fertilized in the same way. All the stigmas which I have seen that are sensitive, stand with one side toward the space visited by insects, and if there are two together, the larger stigma comes next to the body of the insect. —*Buffalo Courier*, Aug. 25, 1876.

2. *On the theory of Evolution;* by Prof. COPE. (Proc. Acad. Nat. Sci. Philad., Feb., 1876.)—Prof. Cope gave a history of the progress of the doctrine of evolution of animal and vegetable types. While Darwin has been its prominent advocate within the last few years, it was first presented to the scientific world, in a rational form, by Lamarck of Paris, at the commencement of the present century. Owing to the adverse influence of Cuvier, the doctrine remained dormant for half a century, and Darwin resuscitated it, making important additions at the same time. Thus Lamarck found the variations of species to be the primary evidence of evolution by descent. Darwin enunciated the law of "natural selection" as a result of the struggle for existence, in accordance with which "the fittest" only survive. This law, now generally accepted, is Darwin's principal contribution to the doctrine. It, however, has a secondary position in relation to the *origin* of variation, which Lamarck saw, but did not account for, and which Darwin has to assume in order to have materials from which a "natural selection" can be made.

The relations exhibited by fully grown animals and plants with transitional or embryonic stages of other animals and plants, had attracted the attention of anatomists at the time of Lamarck. Some naturalists deduced from this now universally observed phenomenon, that the lower types of animals were merely repressed conditions of the higher, or in other words, were embryonic stages become permanent. But the resemblances do not usually extend to the entire organism, and the parallels are so incomplete, that this view of the matter was clearly defective, and did not constitute an explanation. Some embryologists, as Lereboullet and Agassiz, asserted that no argument for a doctrine of descent could be drawn from such facts.

The speaker, not adopting either view, made a full investigation into the later embryonic stages, chiefly of the skeleton of the Batrachia, in 1865, and Prof. Hyatt, of Salem, Mass., at the same time made similar studies in the development of the Ammonites and Nautili. The results as bearing on the doctrine of evolution were published in 1869 (in "The Origin of Genera"). It was there pointed out, that the most nearly related forms of animals do present a relation of repression and advance, or of permanent embryonic and adult type, leaving no doubt that the one is descended from the other. This relation was termed *exact parallelism.* It was also shown, that, if the embryonic form were the parent, the advanced descendant was produced by an increased rate of growth, which phenomenon was called *acceleration;* but that, if the embryonic type were the offspring, then its failure to attain to the condition of the parent is due to the supervention of a slower rate of growth; to this phenomenon the term *retardation* was applied. It was then shown that the *inexact parallelism* was the result of *unequal* acceleration or retardation; that is, acceleration affecting one organ or part more than another, thus disturbing the combination of characters which is necessary for the state of *exact parallelism* between the perfect stage of one animal and the transitional state of another. Moreover, acceleration implies constant addition to the parts of an animal, while retardation implies continual subtraction from its characters, or atrophy. He has also shown (Method of Creation, 1871), that the additions either appeared as *exact repetitions* of preëxistent parts, or as *modified repetitions*, the former resulting in simple, the latter in more complex organisms.

Professor Hæckel, of Jena, has added the keystone to the doctrine of evolution in his Gastræa theory. Prior to this generalization, it had been impossible to determine the true relation existing between the four types of embryonic growth, or, to speak otherwise than that they are inherently distinct from each other. But Hæckel has happily determined the existence of identical stages of growth (or segmentation) in all of the types of eggs, the last of which is the *gastrula;* and beyond which the identity ceases. Not that the four types of gastrula are without difference, but this difference may be accounted for, on plain principles. In 1874, Hæckel, in his "Anthropogenie," recognizes the importance of the

irregularity of time of appearance of the different characters of animals during their period of growth, as affecting their permanent structure. While maintaining the view that the low forms represent the transitional stages of the higher, he proceeds to account for the want of exact correspondence exhibited by them at the present time, by reference to this principle. He believes that the relation of parent and descendant has been concealed and changed by subsequent modifications of the order and appearance of characters in growth. To the original simple descent he applies the term *palingenesis;* to the modified and later growth, *cœnogenesis.* The causes of the change from palingenesis to cœnogenesis, he regards as three, viz: acceleration, retardation, and heterotopy.

It is clear that the two types of growth distinguished by Prof. Hæckel are those which had been pointed out by Prof. Cope in "The Origin of Genera," as producing the relations of "exact" and "inexact parallelism;" and that his explanation of the origin of the latter relation by acceleration or retardation is the same as that of the latter essay. The importance which he attaches to the subject was a source of gratification to the speaker, as it was a similar impression that led to the publication of "The Origin of Genera" in 1869.

It remains to observe that the phenomena of exact parallelism or palingenesis, are quite as necessarily accounted for on the principle of acceleration or retardation, as are those of inexact parallelism or cœnogenesis. Were all parts of the organism accelerated or retarded at a like rate, the relation of exact parallelism would never be disturbed; while the inexactitude of the parallelism will depend on the number of variations in the rate of growth of different organs of the individual, with additions introduced from time to time. Hence it may be laid down, that *synchronous acceleration* or *retardation* produces exact parallelism, and *heterochronous acceleration* or *retardation* produces inexact parallelism.

In conclusion, it may be added that acceleration of the segmentation, the protoplasma or animal portion of the primordial egg, or retardation of segmentation of the deutoplasma or vegetative half of the egg, or both, or the same relation between the growth of the circumference and center of the egg, has given rise to the four types which the segmentation now presents.

An analysis of the laws of evolution may be tabulated as follows:—

Acceleration, which proceeds by { Exact repetition. / Modified repetition. / Heterotopy. }

Retardation, which proceeds by { Exact atrophy. / Inexact atrophy (or senility),* }

and each of the methods may be either of *Exact parallelism*, the product of *Palingenseis*, which is *synchronous;* or *Inexact parallelism*, the product of *Cœnogenesis*, which is *heterochronous.*

3. *Mimicry in Butterflies explained by Natural Selection;* by S. H. Scudder. (Proc. Amer. Assoc., Buffalo.)—Fritz Müller,

* So called by Professor Hyatt.

whose contributions to science are always worthy of especial attention, endeavors in a recent German periodical to show how the phenomena of mimicry in butterflies may be explained by the theory of natural selection. He bases his inquiries upon the species of Leptalis found in southern Brazil; and although, as will appear below, he adduces reasons for believing the primitive stock to have been banded, and not, like most of the family to which the genus belongs, simple white butterflies, he commences by showing how even such an extreme change could be wrought out by the survival of the fittest in the struggle for existence. "Should," he remarks, "the first unimportant variations from the original white color (of the Pierids) be useful only in attracting to their possessors, at a little shorter distance, the attention of enemies flying constantly overhead, they would become more and more useful, and cause their possessors to become continually more abundant in proportion to the type, they could therefore serve as the basis for the gradual formation of a resemblance fit to deceive even the sharp eyes of birds scanning the swarms of Ithonias (the butterflies imitated by some Leptalids) for booty." Further on he asserts that "the acceptance, as the starting point in the origin of mimicry by natural selection, of a resemblance having its beginning at such a distance, can scarcely be shaken by a single known case. It should moreover not escape attention that the sharpsightedness of enemies is itself also a quality at first gradually acquired in the struggle for existence, and one which must increase from the very fact that by protective coloring, mimicry, &c., the persecuted species escapes the less sharp-sighted pursuer. This ever increasing sensitiveness and sharpsightedness of the pursuer on the one hand explains the wonderful completeness of many natural imitations, and, on the other, makes the acceptation of an originally very slight resemblance the less hazardous."

Fritz Müller insists, as all writers on the subject have done, upon the similar geographical distribution of the imitating and the imitated species, as a necessary concomitant of mimicry, but instead of believing, with the other authors, that the Leptalids have become poor flyers in their imitation of the feeble-winged Ithonias; he holds that the wretched powers of flight possessed by the species of Leptalis have been the very cause of mimicry; the insects needed mimicry the more the poorer flyers they were. Mimicking species, of course, stand between their original type and the mimicked species; and, since mimickry is often confined to the female, we should expect in such cases to find the following series: original form, male of mimetic species, female of same. Species mimicked. In his vicinity, Müller has found five species of Leptalis, of which only four are common and discussed by him. Of these four, *Leptalis melia* mimics nothing; all the other three are imitative species, and mimic distinct groups of butterflies; *Leptalis astynome*, resembling a Heliconian-like Danaid, *Mechanitis Lysimnia;* another, which he calls *Leptalis thalia*, mimicking an Acræan, *Acræa thalia*, so closely that Müller at first supposed it to be an Acrean;

and the last, *Leptalis melite*, bearing a close resemblance to the female of one of its own family, *Leptoneura Lycinunia.—Buffalo Daily Courier*, Aug. 25, 1876.

4. *A Preliminary Note on Menopoma Alleghaniensis of Harlan;* by A. R. GROTE, (Proc. Amer. Assoc., Buffalo, 1876.)—I have been able to examine nearly one hundred specimens of the Menopoma Alleghanense, the aquatic salamander living in the tributaries of the Mississippi, taken in the months of July and August in the Alleghany river, at Olean, N. Y. The object of the present communication is to record the fact that the more reddish unicolorous specimens, which have been described as a distinct species under the name of *fuscum* by Holbrook, and which are retained as a distinct species by Prof. Cope in his check list, cannot be considered as a different species from the spotted specimens from which the original description seems to be drawn. We have one species in the tributaries of the Ohio and Mississippi, and not two. The larger, and apparently often the female specimens, are referable to Holbrook's name. Between the two there seems to be all possible grades, and from the same locality, although the two extremes are more numerous, and, at first sight, readily picked out.

I have also to record the fact that the animal sheds a transparent membrane, which I believe is the exterior layer of the skin. While observing this fact in the aquarium of the Buffalo Society of Natural Sciences, Prof. S. W. Garman and myself were able to find an almost complete skin, all the feet and the toes being readily perceived while floating and unfolding it in the water. This same skin was observed at first gathered in the mouth of the animal, which was apparently in the act of swallowing it. This last observation is interesting, since a similar habit had been previously observed in the case of the common toad. All individuals of the Menopoma that I have observed have in the water an intermittent swaying motion from side to side. While I have not been able to verify the conjecture, this movement of the body may be connected with the effort of the animal to get rid of its skin. On the other hand it may be a movement to attract the sexes, or connected with the breeding period.

In *Dactylethra* and *Cyclorhamphus* Prof. Garman has observed a similar shedding of the skin. We may predict that the same thing occurs in the other more exclusively aquatic forms *Necturus tetradactylus* (*Menobranchus lateralis* of authors), *Amphiuma*, *Siren*, and also in the forms that take to the land, as *Amblystoma*, *Plethodon*, *Desmognathus*, and *Diemyctylus*, as well as in *Megalobatrachus* of Japan.

I have to record also the fact that females opened on August 21st, contained well developed eggs attached by a membrane to the ovary.

I finally wish to record the important fact that the eggs are deposited in August. (I exhibit one taken from the aquarium this morning, Aug. 30th, 1876.) The yolk is seen floating freely in a glairy fluid, enveloped in a membrane similar to that containing

the albumen in a bird's egg inside the shell. The eggs are laid in a connected string and impregnations probably occur as they are extruded. The egg takes in water by endosmosis.

The Menopoma frequents the muddy banks of the river, in which to secrete its eggs. In external appearance there is at this time a change, and we may say that the animal puts on its "marriage dress." The tail broadens and there is a plaited extension of the skin, along the sides of the body. The *Menopoma* is nocturnal in its habits.

5. *The Entomological Section of the American Association, Buffalo, N. Y. Address of* Dr. LeConte, *President of the Section.*—After noticing some of the evidences of progress in new publications, etc., Dr. LeConte added:

I would gladly stop here, but a sense of duty to science, and my obligation to you alike forbid silence. I have to speak of a subject of a disagreeable nature.

It is concerning the efforts made by you and other members of the Association at the last meeting at Detroit, to procure the appointment of a Commission for the protection of Agriculture against noxious insects: this Commission to be composed of properly informed men of science, and chosen under such circumstances as would prevent the influence of political bias, or personal favoritism. If I do not fatigue your memory too much, you will recollect the memorials that were so extensively signed, in relation to this subject; copies of which memorials are again before you. These memorials were extensively circulated at the West, and were signed by many of the most influential bodies for the promotion and protection of agriculture in that region. During the winter these memorials were sent to Congress, in the expectation that some proper legislation would follow. One of the Senators, in fact, introduced a bill which seems to have been very carefully considered, and indeed bears upon its face some evidence of scientific guidance. This bill provided for the appointment of three Commissioners for five years: the Commissioners to be nominated by the Council of the National Academy of Sciences to the Secretary of the Interior. This bill, having been referred to the Committee on Agriculture, was returned so altered in form as to provide for one Commissioner, to be appointed by the Department of Agriculture, the very enemy and incubus from which the western agriculturists specially desired to be relieved.

The bill in this form passed the Senate, several of the members taking occasion in the discussion which preceded the passage, to talk to the demonstration of their own ignorance of the subject. However, this discussion has been already so severely commented upon in several of the newspapers of the Mississippi valley, that it is quite unnecessary for me to add anything farther, except the hope that the Legislature which chooses the successors of those Senators will have men of better education and higher intelligence offered to them as candidates for the position.—*Buffalo Daily Courier*, Aug. 25, 1876.

6. *Manual of the Vertebrates of the Northern United States;* by D. S. JORDAN. 12mo, 342 pp., no figures. Chicago: 1876. (Jansen, McClurg & Co.)—To collectors and others who chiefly desire to ascertain the names of species, this will doubtless prove to be a very convenient and useful work, especially if they have already acquired considerable familiarity with the subject by the use of more elaborate works. But it will prove of little value as a genuine Natural History of our vertebrates. Inasmuch as works of this class naturally tend to foster the already too prevalent idea that the study of "zoology" and "botany" means only, or chiefly, the learning of the names and habits of animals and plants, they may, in many cases, do more to hinder than to help the true progress of these sciences. In the present work we find little more than the shortest and most meagre descriptions of the species, usually without any reference whatever to habits, while the characters of the genera cannot be ascertained, in most cases, except by the use of "analytical tables," which are, for the most part, highly artificial. The descriptions of the families and orders are likewise very brief and technical. At most, it should be regarded only as a convenient key or index to the names and classification of the species included in it. But on this very account, the absence of synonyms and of all references to more important works, in which the species are fully described or figured, is a very serious defect, which renders it far less useful than it otherwise might have been. A mere list of the numerous important works from which the author has compiled his book would have been of far more use to most students than any other part of the book of similar extent. Although the author, in the preface, admits that he has compiled his materials from numerous authors, he seldom indicates, in the body of the work, from what special work, or even from what author, a statement or description has been borrowed. The reliability of such compilations depends so directly upon the works used in compilation, that some indication should always be given of the source of the statements, and this could easily have been done without materially increasing the size or cost of the book. The copious index and glossary at the end are good features.

There are, as might have been anticipated, many inaccuracies, and also some important omissions of species. The genus *Neosorex*, of which a species (*N. palustris*) was described by the writer from Maine and Massachusetts,* and by Prof. Cope, from New Hampshire, is not mentioned at all. There are but two species of *Sorex* mentioned, while there are certainly three, and perhaps four species in New England. *Blarina angusticeps*, a well marked form, is also omitted. The American bears are all reduced to one species, in accordance with Mr. J. A. Allen's former views, which, however, he has since discarded, as noticed in the last number of this Journal. Among the fishes, where there is some original matter, the author has, in some genera, rejected or ignored many species

* Proceedings Boston Soc. Natural History, vol. ix, p. 164, 172, 225, 1862. See also *N. fimbripes* (Bachman, sp.) from Pennsylvania.

recognized by other writers, which is an easy, if not satisfactory, way, of jumping difficult subjects. This is especially the case in the Salmonidæ and Catostomidæ. V.

7. *The Five Senses of Man;* by JULIUS BERNSTEIN. International Scientific Series. 301 pp., 91 wood-cuts. New York: 1876. (D. Appleton & Co.)—In this work the author has presented very clearly, and in a pleasing manner, the more important facts and theories concerning this interesting subject, together with statements of the numerous observations and experiments recently made, relating to the senses. As many of these recent investigations are not included in the text-books and treatises ordinarily used, this book will be of general interest. V.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *On the fall of a Meteorite in Kansas City, Missouri, in June,* 1876; by JOHN D. PARKER. (Letter to Editors dated Kansas City, Mo., Aug. 2, 1876.—On June 25, 1876, between the hours of nine and ten in the morning, a small meteorite fell upon the tin roof of Mr. Isaac Whittaker's business house, No. 556 Main street, Kansas City, Mo. The meteorite came down with sufficient force to cut a hole in the tin roof on the front part of the house near an open window, but not passing entirely through the tin, it bounded back a few feet and lay on the roof. Mrs. Baker, who occupies rooms in the front part of the house in the second story, and Mrs. Whittaker were standing near the window when the meteorite fell, and heard the sharp concussion when it struck the roof. Mrs. Baker immediately picked up the meteorite as it lay near her on the roof, but dropped it again, finding it too hot to retain it in her hand.

The meteorite is a plano-convex specimen, about one and three-quarter inches in diameter, and about one-third of an inch in thickness. The outside or convex surface possesses the usual crusted appearance, while the inside or plane surface differs from ordinary meteorites in possessing the appearance of sulphuret of iron, subjected to some degree of heat, instead of nickeliferous iron. One might easily infer that the meteorite was shaled off from a large bolide that passed over the city at that time. As it fell in the city, I have named it the Kansas City Meteorite. It has not been subjected to chemical analysis.

2. *American Association for the Advancement of Science, at Buffalo.*—The meeting of the Association at Buffalo opened on Wednesday, on the twenty-third of August. Prof. WILLIAM B. ROGERS was the President of the meeting. The address of the retiring President, Mr. J. E. HILGARD, of the Coast Survey, treated of the recent progress in the department of Geodesy, and especially of the work accomplished in the United States. There were addresses also by the Vice-Presidents of the sections, Prof. C. A. YOUNG giving a review of recent Astronomical progress, Prof. E. S. MORSE, of work done in North America in connection

with the subject of Evolution; and Prof. G. F. BARKER treating of "the Atom and the Molecule."

The number of members present was large, and the hospitality of the citizens of Buffalo unbounded. Besides other entertainments, there was, without expense to the members, an excursion on Saturday to Niagara Falls, where a generous lunch was furnished them by Mr. John L. Bush at his mansion; and on the following Wednesday, over the Chautauqua Lake, to Jamestown, seventy miles. Between four and five hundred persons went on these excursions.

A number of distinguished foreign men of science were present —among them Prof. Huxley; Prof. Otto Torell, Dr. J. Lindahl and J. Nordström, of Sweden; Prof. E. H. von Baumhauer, of Haarlem; Mr. W. Sagel, of Vienna; R. Kœnig, of Paris; and Signor Castellani, of Rome. Prof. Huxley was received with a vote of welcome amid much applause.

The officers elected for the next meeting of the Association are as follows: Prof. SIMON NEWCOMB, President; Prof. EDWARD C. PICKERING, Vice-President of the Physical section; Prof. O. C. MARSH, Vice-President of the section of Geology and Natural History; Prof. N. T. LUPTON, Chairman of the Chemical subsection; Prof. DANIEL WILSON, Chairman of the subsection of Anthropology; R. H. WARD, Chairman of the subsection of Microscopy; A. R. GROTE, General Secretary; F. W. PUTNAM, Permanent Secretary; WM. S. VAUX, Treasurer. The Association adjourned to meet in 1877, at Nashville, Tennessee, on the last Wednesday of August.

The following is a list of the papers read at the meeting or accepted for reading.

I. *Physical Section.*

On the practicability of cooling the air of buildings during hot weather; S. NEWCOMB.

Note on the radiometer, T. C. MENDENHALL.

Certain new constructions in graphical statics, H. T. EDDY.

Spectroscopic observations on the sun's rotation, C. A. YOUNG.

On some recent spectroscopic observations of the zodiacal light, A. W. WRIGHT. Volatilization of metals by the electrical discharge, id.

On Kent's table of one-quarter squares of numbers, S. J. COFFIN.

A new fundamental method in graphical statics, H. T. EDDY.

On the Iowa weather stations, G. HINRICHS.

Phenomena produced by the union of two sounds, R. KŒNIG.

Discussion of the general principles of construction of ordinary and perfect magic squares, J. D. WARNER.

Physics of the Gulf of Mexico and the Mississippi River, C. G. FORSHEY.

Solar influence on the degradation of soils by aqueous action, T. MCWHORTER.

The specific gravity of lead, P. SCHWEITZER.

Co-ordinate surveying, H. F. WALLING.

Some remarks on the use and interpretation of particular integrals which satisfy general differential equations expressive of dynamic problems, suggested by Laplace's dynamic theory of the tides, J. G. BARNARD.

Determinations of subjective temperature, J. W. OSBORNE. The accurate graduation of thermometers by comparison, id. Experiments on the gyration of liquid masses in rotation, id.

Observations on the diurnal variation in the humidity of the air, H. HAMMER.

On the increase of index of refraction accompanying change of temperature, T. C. MENDENHALL.

Dielectric polarization, E. ROOT.

Essay on the molecular character of steam, S. M. ALLEN.

A tide gauge for use in cold climates, J. M. BATCHELDER.

Meteorites of Amana, Iowa Co., Iowa, G. HINRICHS.

On the distribution of errors in numbers written from memory. F. E. NIPHER.

Account of a series of experiments on the refrigeration of air by expansion, P. H. Van der WEYDE.

On the combined compression and stage-forceps carrier, R. H. WARD.

Proposed method of evolution, J. D. WARNER.

Exhibition of capillary coke, from Tracy City, Tenn., N. T. LUPTON.

Relative market prices of gold and silver, and their influence on the metallic monetary standard of the United States, E. B. ELLIOTT. Prices of the bonded securities of the United States and the corresponding rates of interest realized to investors, id.

II. *Section of Geology and Natural History.*

On the mode of extrusion of the ova in Limpets, W. H. DALL.

On the origin of kames or eskers in New Hampshire, W. UPHAM.

Some new points regarding the tongue of Picus viridis, J. LINDAHL.

On the geology of Eastern Pennsylvania, T. S. HUNT.

Note upon the geological position of the serpentine limestone of Northern New York, and an inquiry regarding the relations of this limestone to the Eozoon limestone of Canada, J. HALL.

On the plastidule hypothesis, L. ELSBERG.

On self-fertilization and cross-fertilization in flowers, T. MEEHAN. On graft hybrids, id.

The water-lime group of Buffalo, A. R. GROTE and W. H. PITT.

On the provisional hypothesis of Pangenesis, W. K. BROOKS.

On a new species of Argulus, A. H. TUTTLE. Notes on the myriapods of Ohio, id.

The slight morphological value of natural attitude and numerical composition, B. G. WILDER. Notes on the brains of fish-like vertebrates; myxinoids, sharks and skates, chimæra, teleosts, id. Notes on the North American Ganoids, id.

The origin and mode of formation of the Great Lakes, J. S. NEWBERRY.

The relations of the rocks of Ohio to those of Pennsylvania and New York, id.

Principal characters of American Pterodactyles, O. C. MARSH.

Note on the pitchstones of Arran, F. A. GOOCH.

On *Sycotypus canaliculatus* Linn., F. W. SIMONDS.

A brief comparison of the butterfly faunas of Europe and eastern North America, with hints concerning the derivation of the latter, S. H. SCUDDER.

On the reciprocal relations of certain genera of articulated brachiopods, W. H. DALL.

New facts relating to *Eozoön Canadense*, J. W. DAWSON.

On the siphon of Endoceras, a genus of chambered shells, A. WINCHELL.

On the post-glacial history of Sequoia gigantea, J. MUIR.

Variation in color in animals, S. W. GARMAN.

Description of new fungus on the leaves of the pear tree, W. H. SEAMAN.

The edible crab of Maryland, *Callinectes hastatus* (Ordway), P. R. UHLER.

Phyllotaxis of cones, W. J. BEAL. Can the Unios see? id. Cross-fertilization of the apple blossoms, id. Sensitive stigmas as an aid to cross-fertilization of flowers, id.

Biological notes on the army worm (*Leucania puncta* Haw), C. V. RILEY.

A preliminary note on *Menopoma Alleghaniensis* of Harlan, A. R. GROTE.

On the origin of mineral veins, C. WHITTLESEY.

A supplement to the glacial theory, W. C. KERR.

Evidences in Boone Co., Ky., of glacial or ice deposits of two distinct and widely distant periods, G. SUTTON.

On the burial place of the Yorkshire Mastodon, discovered in Broome Co., N. Y., T. B. COMSTOCK. Some unexplained phenomena in the Geyser Basins of the Yellowstone National Park, id. The "two-ocean water," the union of the Atlantic and Pacific Oceans in the Rocky Mountains, id.

III. *Subsection of Chemistry.*

The relationship of structure, density and chemical composition in steel, J. W. LANGLEY.

On the limit of reliability in the indirect estimation of sodium and potassium chlorides, H. W. WILEY. Some modified forms of apparatus; flue with artificial draft, flue with artificial draft and air bath, apparatus for sugar and fat extraction, id. Some indigenous Indiana woods, their specific gravity, per cent of ash in wood and bark, id.

On the chemical composition of a saline efflorescence occurring at Goat Island, E. W. MORLEY.

A note upon the rocks of the Galapagos Islands, F. A. GOOCH.

On the chemical composition of Pennsylvania petroleum, S. P. SADTLER.

Contribution to the chemistry of hydrogen, A. R. LEEDS.

Upon the reduction of silver at ordinary temperatures in the presence of free nitric acid, id.

On a siliceous deposit from the interior of a hollow mass of limonite, with observations on the molecular movements of finely divided matter, N. T. LUPTON.

On the so-called alkali of the western plains, B. S. HEDRICK.

On the analysis of milk, E. H. v. BAUMHAUER.

Notes of a mineralogical tour in Western North Carolina, made under the auspices of the State survey, A. A. JULIEN and H. C. BOLTON.

A sugar analysis, A. SPRINGER.

Action of moderate heat on bituminous coal, E. T. COX.

Dissociation of phosphorus in the blast furnace, W. H. CHANDLER and E. H. BAILEY. Nitrates in natural waters and in Lechauweki spring water, id. Determination of nitric acid, id.

IV. *Subsection of Microscopy.*

Results of measurements of eleven of Möller's Diatomaceen Probe-platten, E. W. MORLEY.

Micrometric measurements of rulings on glass, by Mr. ROGERS.

Micrometric measurements of rulings on glass, by Mr. RUTHERFORD.

Results obtained by double staining of muscular tissue of Amphiura with picric acid and carmine, G. BEATTY.

Simple means of adopting the binocular microscope to defects in the eye, W. H. BULLOCK.

Remarks on some American contributions to the development of the modern microscope, R. H. WARD.

On a new system of finder for the microscope.

On a few simplifications of the polarizing and of the spectroscopic microscope.

On some modifications and special attachments to the microscope for chemical research, P. H. VAN DER WEYDE.

V. *Subsection of Anthropology.*

Peculiarities of the femora from tumuli in Michigan, H. GILLMAN. Investigation of the burial ground at Fort Wayne on the Detroit river, Michigan, id. Some observations on the orbits of the crania from mounds, id.

The international symbols for charts of prehistoric archæology, O. T. MASON. The scope of anthropology, and the classification of its materials, id. Archæological collections from Porto Rico, id.

The Iroquois phratry, L. H. MORGAN. The Iroquois gens, id. The Iroquois confederacy, id.

Etruscan and Greek art in Jewelry, and its revival, A. CASTELLANI.

Hybridity and absorption among the races of the New World, D. WILSON.

On the mythology of the North American Indians, J. W. POWELL.
Brain-weight and size in relation to the relative capacity of races, D. WILSON.
On some fragments of pottery from Vermont, G. H. PERKINS.
On the ancient and modern Pueblo tribes of the Pacific slope of the U. S., E. A. BARBER.
The mood of the verb in conditional clauses, ISAAC B. CHOATE.
The museums of industrial art in Austria, HEINRICH FRAUBERGER.
The archæology of Europe and America compared, S. D. PEET. On the state of society in the Primitive age, id.

3. *Geographical Distribution of Plants and Animals;* by C. PICKERING, Wilkes' U. S. Exploring Expedition, author of the Races of Man. Part II, Plants in their wild state. 524 pp. 4to, with several colored maps. Salem, Mass. (Naturalist's Agency.)—This work, completing Dr. Pickering's Report on the Geographical Distribution of Plants and Animals, is the result of extensive personal observation about the world as well as of much study. It is a large storehouse of facts, on a subject of general interest, gathered with great labor and fidelity. It gives observations with regard to the characteristic plants and predominant botanical features of all the various islands and continental regions visited by the Exploring Expedition under Captain (now Admiral), Wilkes, and also many collateral facts on climate, topography, scenery, etc., that came under the author's observation. The text is illustrated by maps of the world, presenting by colors the conclusions arrived at by the author.

4. *Proceedings of the Davenport Academy of Natural Sciences.* Vol. 1, 1867–1876. 284 pp. 8vo, with 35 plates. Davenport, Iowa, 1876.—This first volume of the Proceedings contains a number of very valuable papers on mounds and mound-builders, by R. J. Farquharson, M.D., W. H. Pratt, A. S. Tiffany, C. Lindsley, and J. D. Putnam, with 34 plates, full of figures representing the structure of mounds, flint and other stone implements, pipes of the form of birds, frogs, and other animals, woven cloth, copper axes, awls, beads, and ear-drops, silver ear-drop, bone knives, pottery, skulls, etc., from different mounds, illustrating a paper by Dr. Farquharson. There are also Zoological articles by J. D. Putnam; Botanical notes by Dr. C. C. Parry; and lists of species of plants, and of land and fresh-water shells, of Coleoptera, Lepidoptera, Hymenoptera, of the vicinity of Davenport, besides other papers.

OBITUARY.

EBENEZER S. SNELL, of Amherst College, Massachusetts, Professor of Mathematics and Natural Philosophy, died, September 18th, aged seventy-five years.

Prof. CHARLES DAVIES, author of various mathematical works, a graduate of West Point of distinction, and from 1857 to 1867 Professor of Mathematics in Columbia College, died September eighteenth, in his seventy-ninth year.

THE

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[THIRD SERIES.]

ART. XXXVIII.—*Observations on the Displacement of lines in the Solar Spectrum caused by the Sun's rotation;* by Professor C. A. YOUNG, of Dartmouth College.

[THE substance of this paper was read at the Buffalo Meeting of the American Association for the Advancement of Science, August 24th, 1876.]

Renewed interest in the question as to the effect of the motion of a luminous body in altering the wave length of the emitted light, has lately been excited by Van der Willigen's mathematical papers upon the subject, and the recent criticisms of Secchi upon the spectroscopic determinations of stellar motions published by Huggins, Vogel, Christie and others. The former, it will be recollected, impugns the received doctrine on mathematical grounds, and it must be acknowledged, that, although his reasoning is not admitted to be conclusive by most astronomers, it has produced a wide-spread distrust, which has been strengthened by the papers of Secchi. The objections of the latter seem however to have been fairly met by the reply of Mr. Christie, recently published in the Monthly Notices, showing the substantial agreement of the results obtained by the different observers after they had learned the delicate precautions essential to success in such observations.

Certainly it seems little short of self-evident that, whenever a point is communicating periodic vibrations to any medium whatever, and, by means of this medium, transmitting them to a second point at a distance, then the frequency, or virtual wave length, of these pulses received at the second point must

be affected by any relative motion of approach or recession between it and the source of the vibrations.

It is not difficult to verify this conclusion in the case of sound waves. The beautiful experiments of Vogel, lately published, show as the result of careful quantitative measurements, that the pitch of a locomotive whistle actually undergoes the precise alterations which theory requires, when the engine is either approaching the observer, or receding from him at a known velocity.

Undoubtedly a considerable point would be gained if we could obtain a similar verification in the case of light—if an alteration in the luminous pitch or wave length, produced in a ray of light by some known rate of motion, could actually be made sensible, measured, and shown to coincide with theory within observational limits of error. This verification unfortunately is not easy to obtain, because the velocity of light is so enormous that it is difficult to find an object sufficiently bright, and moving rapidly enough, to make the change of wave length perceptible in our instruments.

I think it was Zöllner who first suggested that the rotation of the sun might furnish the desired test, since its eastern and western limbs have a relative motion of nearly $2\frac{1}{2}$ English miles per second along the line of sight. But the displacement of lines in the spectrum due to this velocity is so small (in the case of the D lines about $\frac{1}{17}$ of the distance between them) that the dispersive power of the instruments heretofore employed by most observers, has been insufficient to make it clearly evident. Vogel alone (in 1871) seems to have succeeded in getting any measurements; his results for the sun's equatorial velocity of rotation ranging from 0·35 to 0·42 of a geographical mile, or from 1·62 to 1·94 English miles.

By using a diffraction grating, however, combined with a prism in such a way as to separate the overlapping spectra of the higher orders from each other, as described in my recent note* on the duplicity of the 1474 line, it is possible to obtain much greater dispersive power, and the displacement then becomes quite sensible.

The apparatus which I have employed consisted of a very fine diffraction grating of 8,640 lines to the inch (for which I am indebted to Mr. Rutherfurd) combined with a telescope and collimator each of $2\frac{1}{4}$ inches aperture and sixteen inches focal length, and a prism of 45° inserted between the grating and the object glass of the eye-telescope. The refracting edge of the prism was of course perpendicular to the lines on the grating. The grating, collimator, &c., were mounted on a wooden framework constructed for the purpose, and arranged to be

* This Journal, June, 1876.

attached to the $9\frac{1}{2}$ inch Equatorial of the Dartmouth College Observatory, in place of its ordinary spectroscope. Undoubtedly a metallic mounting would have been firmer and better, but with careful manipulation the wooden arrangement answered reasonably well. The eye-telescope and collimator were at a fixed inclination, and the spectra of the different orders were brought into the field of view by turning the grating in the plane of dispersion. This of course made the dispersive power quite different for the spectra of the same order on opposite sides of the image of the slit. The eye-telescope magnified about twenty times and was provided with a micrometer* borrowed from one of the reading microscopes of the meridian circle.

Between the two D lines, the spectra of the sixth and eighth orders usually showed no less than eight other lines, most of which are supposed to be water lines, produced by the vapor in our atmosphere, and therefore of course not subject to displacement by the sun's rotation. I was in hopes to make use of them as reference points, and to determine the displacement of the D lines by simply measuring the intervals with the micrometer. I soon found, however, that the atmospheric lines were too faint and shadowy to admit of sufficient accuracy of bisection, especially by the rather coarse threads with which the micrometer had been provided for the purpose of observing in a feeble light. I was accordingly compelled to make the observations as follows—

The grating having been adjusted so as to bring the group of lines to be observed into the center of the field of view, the spectroscope was turned around the optical axis of the telescope until the slit was accurately north and south, so that, if placed tangent to the eastern limb of the sun, a motion of the Right Ascension tangent screw would bring the western limb to tangency. Of course proceeding in this manner the observations were made at points not precisely on the sun's equator, but having a solar latitude ranging from 2° to 15°, according to the date. It was thought better to do this, however, than to risk the disturbance which might be produced by using the Declination tangent screw, which sometimes worked a little jerkily. The slit was then accurately adjusted to the focal plane of the sun's image, and the collimator and the eye-telescope were focused carefully for distinct

* The value of one revolution of the micrometer screw (whose head was graduated into 60 divisions,) was about 4′ 9″; but it was continually varying by a slight amount, since in adjusting for distinct vision of the spectrum no pains was taken to keep the distance between the object glass and the cross hairs strictly constant. This will account for the small variations of the measured intervals between the same lines as determined on different occasions—variations considerably exceeding the probable errors of reading.

vision; after this no adjustment of either telescope or spectroscope was touched in the slightest until the observation was complete. The slit being placed nearly tangent to the limb of the sun, and the driving clock started, a series of micrometer readings was made upon the different lines in the group to be observed, first running the micrometer wires one way and then back, thus obtaining two readings for each line. Then the Right Ascension tangent screw was gently turned until the opposite limb was brought to the slit, and the micrometer readings were repeated, running down and back *twice*, so as to give four readings of each line; finally, moving the tangent screw so as to bring back the limb first observed, another set of readings was taken, two on each line, which finished the observation. The object of this arrangement of readings is of course to detect any possible disturbance of the instrument during the work, and to eliminate the effect of the earth's rotation, or of any uniformly progressive change in the relative positions of the collimator, grating, and eye-telescope, due to slight alterations of flexure caused by the motion of the telescope. Each reading given in the following tables is therefore the mean of four. The probable error of a single reading (due to inaccuracy of bisection or instrumental disturbance, but not of course including possible constant errors) was found to be about $\frac{3}{10}$ of one micrometer division; so that the probable error of each reading given in the tables is about 0·15 of a division.

It did not occur to me until near the end of the observations that, with the slit *tangent* to the sun's image, the heat would tend to displace the line of collimation by expanding the slit-plate more on one side than the other, and slightly bending the tube to which it is attached. Since, however, the effect would be in opposite directions according as the grating was inclined so as to throw the reflected slit-image to the right or the left, this effect must be nearly eliminated from the final mean. In some of the observations of Aug. 12, it was eliminated by inverting the spectroscope, i. e., rotating the whole spectroscope 180°, around the line of collimation; this, however, in one of the series of readings always brings the eye-piece into an inconvenient position. One set of observations on Aug. 12, was made with the slit *radial* to the sun's image—in this case the heat of the image has no injurious effect, but it is much more difficult to point the micrometer on the *end* of a line than on its middle, and the probable errors of reading are more than doubled.

The formulæ employed in reducing the observations are as follows: Let U= the relative velocity of two opposite points of the sun's equator, and $d\lambda$ the corresponding change of wave length of a spectrum-line, whose wave length is λ; also let the

velocity of light = 186600 English miles per second, according to the latest determination of Cornu. Then, by Doppler's theory,

$$U = 186600 \times \frac{d\lambda}{\lambda}. \quad (1)$$

If now, in any group or spectrum lines of small extent, I is put for the difference of wave length of the extreme lines of the group; Δ for the interval between the extreme lines measured in micrometer units, and δ for the displacement as indicated by the difference between the micrometer readings on a given line when the slit is placed on the eastern and western limbs of the sun's image respectively, we shall have

$$d\lambda = I \times \frac{\delta}{\Delta}, \text{ and } U = 186600 \frac{I}{\lambda} \times \frac{\delta}{\Delta}, \quad (2)$$

where λ of course is to be taken as the *mean* wave length of the group.

Taking Angström's wave lengths, we find for the D group $U = 190{\cdot}3 \frac{\delta}{\Delta}$, and for the 1474 group $U = 361{\cdot}1 \frac{\delta}{\Delta}$; which amounts to saying that a velocity of 190·3 English miles would displace one of the D lines by a space equal to the distance between them, and for the other group a velocity of 361·1 miles would be required.

From the sun's known dimensions and period of rotation, adopting Faye's numbers, the equatorial velocity of its surface is easily found to be 1·248 English miles per second; U, of course, ought to come out double this, or 2·496.

The tables need little explanation; the expression "grating right," means that the grating was so inclined as to throw the reflected image of the slit to that side of the collimator which was remote from the eye-telescope. In this position the spectra were more dispersed, but less satisfactorily defined than those of the same order obtained by turning the grating "left," i. e., toward the eye-telescope. The first column contains the designation of the line observed; the second, headed "west," gives the reading of the micrometer obtained at this limb; the fourth, headed "east," gives the reading of the eastern limb; the third, headed "mean," contains the mean of the numbers in the second and fourth columns, expressed in divisions of the micrometer head; the difference between these, given at the bottom of the column is Δ. The fifth column contains the differences between the numbers in the second and fourth columns, and their mean, given at the bottom of the column, is δ.

In the earlier observations of the D group several other lines were observed besides the three given, but they were so faint that the readings were very discrepant, sometimes to the extent

of two or three divisions, and they are therefore omitted. The readings of the nickel line are retained, though far less reliable than those of the two Ds.

(1.) July 10, 1876; 9.30 to 10.15 A.M. (civil time); grating *right;* spectrum of 6th order; definition poor.

	West.	Mean.	East.		
	r d	d	r d		
D_1	4 45·65	284·70	4 43·75	1·90	$\frac{\delta}{\Delta}=0·0186$
Ni	3 52·90		3 49·75	2·15	U=3·55
D_2	2 59·00	178·05	2 57·10	1·90	
		$\Delta=106·65$		$\delta=1·98$	

If we reject the nickel line $\delta'=1·90$, $\frac{\delta'}{\Delta}=0·0178$

and $U'=3·33$.

(2.) July 10; 10.30 to 11.10 A.M. D lines; grating *right;* spectrum of 6th order; definition medium.

	West.	Mean.	East.		
	r d	d	r d	d	
D_1	4 26·40	265·57	4 24·75	1·65	$\frac{\delta}{\Delta}=0·0187$
Ni	3 32·05		3 29·65	2·40	
D_2	3 39·95	158·97	3 38·00	1·95	U=3·57
		d $\Delta=106·60$		$\delta=2·00$	

Rejecting the nickel line, $\delta'=1·80$; $\frac{\delta'}{\Delta}=0·0169$, $U'=3·22$.

(3.) July 10: 11.35 to 12.00 A.M. D lines; grating *left;* spectrum 6th order; definition fine.

	West.	Mean.	East.		
	r	d	r d	d	
D_1	4 13·50	253·87	4 14·25	0·75	$\frac{\delta}{\Delta}=0·0126$
Ni	4 51·00		4 51·82	0·82	
D_2	5 16·87	317·28	5 17·70	0·83	U=2·40
		$\Delta=63·41$		$\delta=0·80$	

(4.) July 15; 10.15 to 10.40 A.M. Observation interrupted by clouds when half completed. D lines; grating *right;* spectrum 6th order; definition poor.

	West.	Mean.	East.		
	r d	d	r d	d	
D_1	5 08·40	308·15	5 07·90	0·50	$\frac{\delta}{\Delta}=0·0061$
Ni	4 12·70		4 12·00	0·70	U=1·16
D_2	3 22·05	201·67	3 21·30	0·75	**This observation is entitled to little weight.**
		$\Delta=106·48$		$\delta=0·65$	

(5.) August 10; 9.30 to 10.40 A. M. Twice the usual number of readings taken. D lines; grating *left;* spectrum 7th order; definition excellent.

	West. r d	Mean. d	East. r d	d	
D_1	0 33·30	33·27	0 34·25	0·95	$\frac{\delta}{\Delta}=0·0146$
Ni	1 13·47		1 15·00	1·53	U=2·78
?	1 36·25		1 37·40	1·15	This observation deserves *double* weight, on account of the number of readings and lines observed.
D_2	1 52·92	113·45	1 53·97	1·05	
		Δ=80·18 d		δ=1·17	

(6.) August 10; 11.10 to 11.50 A. M. D lines; grating *right;* spectrum 6th order; definition poor.

	West. r d	Mean. d	East. r d	d	
D_2	2 18·70	137·63	2 16·55	2·15	$\frac{\delta}{\Delta}=0·0188$
Ni	1 25·65		1 22·85	2·80	U=3·59
D_3	0 32·05	31·52	0 31·00	1·05	
		Δ=106·11		δ=2·00	

Rejecting the nickel line, $\delta'=1·60$, $\frac{\delta'}{\Delta}=0·0151$ $U'=2·87$.

(7.) August 12; 9.30 to 10.10 A. M. 1474 group; grating *left;* 8th order; definition fine;* instrument *inverted.*

	West. r d	Mean. d	East. r d		
K 1463_2	2 51·72	172·22	2 52·72	1·00	$\frac{\delta}{\Delta}=0·00783$
1467	3 51 00		3 52·28	1·28	
	4 49·65		4 51·60	1·95	U=2·66
1474	5 49·20	349·71	5 50·23	1·03	
		Δ=177·49		δ=1·31	

(8.) August 12; 10.35 to 11.10 A. M. 1474 group; grating *left;* spectrum 8th order; instrument *erect;* definition fine.

	West. r d	Mean. d	East. r d	d	
K 1474	2 29·90	149·32·	2 28·75	1·15	$\frac{\delta}{\Delta}=0·00666$
1467	4 28·00		4 26·82	1·18	
1463_2	5 27·63	326·61	5 26·42	1·21	U=2·41
		Δ=177·29 d		δ=1·18 d	

(9.) August 12; 11.30 A. M. to 12.20 P. M. 1474 group; grating *left;* spectrum 8th order; slit *radial;* definition fine.

	West. r d	Mean. d	East. r d	d	
K 1463_2	0 52·92	53·46	0 54·00	1·08	$\frac{\delta}{\Delta}=0·00651$
1467	1 52·85		1 54·15	1·30	U=2·35
1474	3 51·18	231·72	3 52·27	1·09	
		Δ=178·26		δ=1·16	

* The definition was such that 1474 constantly showed double, and on moving the slit to the base of the chromosphere, the bright line which appeared was clearly seen to coincide with the more refrangible of the two components.

Since the points observed were not situated upon the solar equator it is necessary to correct each result by multiplying it by a factor depending upon the heliographic latitude, φ, of the point. If the sun's surface rotated as a coherent mass the factor would be simply, sec. φ. Since this is not the case however, the expression becomes more complicated. Adopting Faye's constants and formula of solar rotation, we find the factor,

$$f=\frac{1}{\cos\varphi(1-0{\cdot}216\sin^2\varphi)}.$$

On July 10, $\varphi=2°$, $f=1{\cdot}001$; on July 15, $\varphi=3°$, $f=1{\cdot}002$; on Aug. 10, $\varphi=14°$, $f=1{\cdot}044$; on Aug. 12, $\varphi=15°$, $f=1{\cdot}051$.

Applying the corrections we have the following, in which the column headed $U\varepsilon$, gives the results without discrimination, while the column $U'\varepsilon$ contains the results obtained by throwing out the nickel line in observations (1), (2) and (6), and rejecting entirely (4), while (5) is counted twice, as having double weight for the reasons assigned.

		$U\varepsilon$		$U'\varepsilon$
	(1)	3·55	(1′)	3·33
	(2)	3·57	(2)	3·22
	(3)	2·40	(3)	2·40
	(4)	1·16	(4)	2·90
	(5)	2·90	(5)	2·90
	(6)	3·75	(6)	2·99
	(7)	2·80	(7)	2·80
	(8)	2·53	(8)	2·53
	(9)	2·47	(9)	2·47
Mean		2·79 ± 0·18		2·84 ± 0·07

The two results do not differ materially, but the second is much more reliable. It makes the velocity of the sun's rotation 1·42 miles per second, while direct observation gives 1·25; perhaps the difference is no more than might be expected; still the difference of 0·34 between the values of U as determined spectroscopically and directly is so many times larger than the probable error of the spectroscopic result, that I am much inclined, especially considering the agreement with Vogel's result, to think it indicates a physical fact, and that the solar atmosphere really sweeps forward over the underlying surface, in the same way that the equatorial regions outstrip the other parts of the sun's surface. If the equatorial acceleration is produced by external causes such an effect would be likely.

It may be interesting to add, that on Aug. 10, a careful series of readings was made on a principal line of the B group, in the spectrum of the 6th order, with entirely negative results; as was to be expected, since the line is atmospheric. The mean of ten readings at the west limb was $56^d{\cdot}22$, at the east limb $56^d{\cdot}23$.

Hanover, N. H., Sept. 12, 1876.

ART. XXXIX.—*Researches in Acoustics;* by ALFRED M. MAYER. Paper No. 8, containing:

1. On the obliteration of the sensation of one sound by the simultaneous action on the ear of another more intense and lower sound.
2. On the discovery of the fact that a sound even when intense cannot obliterate the sensation of another sound lower than it in pitch.
3. On a proposed change in the usual method of conducting orchestral music, indicated by the above discoveries.
4. Applications of the interferences of sonorous sensations to determinations of the relative intensities of sounds.

THIS communication is preliminary to an elaborate paper on the above subjects. For conciseness and clearness, I present the few facts I have now to offer in the form of notes of experiments:—

1. *On the obliteration of the sensation of one sound by the simultaneous action on the ear of another more intense and lower sound.*

Experimental Observations on the Obliteration of one Sound by another.—Several feet from the ear I placed one of those loud-ticking spring-balance American clocks, which make four beats in a second. Then I brought quite close to my ear a watch (made by Lange, of Dresden) ticking five times in the second. In this position I heard all the ticks of the watch, even those which coincided with every fourth tick of the clock. Let us call the fifth tick of the watch which coincided with one of the ticks of the clock, its fifth tick. I now gradually removed the watch from the ear, and perceived that the fifth tick became fainter and fainter, till at a certain distance it entirely vanished, and was, so to speak, "stamped out" of the watch.*

Similar and more striking experiments were made with an old silver watch, beating four times to the second, by causing this watch to gain about thirty seconds an hour on the clock, so that at every two minutes the ticks of the watch and clock exactly coincided. When the watch was held near the ear, every one of its ticks was heard distinctly; but on gradually removing it from the ear, the ticks of the watch became fainter

* In the publication of this paper in Nature, Aug. 10, 1876, my friend Mr. Alexander J. Ellis, F.R.S., appends the following note to the above experiment:—"The precise number of ticks in a second here mentioned are not necessary for roughly observing and understanding these phenomena. I observed them by a common American pendulum clock placed on a table, which increased the power of its half-second ticks, and a watch beating five times in two seconds. Rev. Mr. Haweis informs me that he has often noticed a similar effect at night with ordinary watches. The sensation produced by the obliteration of the tick, when the proper distance of the watch from the ear has been attained, and the consequent sudden division of the ticks into periods separated by silences, is very peculiar. It is difficult not to believe that some accident has not suddenly interfered with the action of the watch, instead of merely with our own sensations."—A. J. E.

and fainter at the coincidences, and when the watch had been removed to a distance of nine inches from the ear, the ticks of the watch were utterly obliterated during *three* whole seconds of its ticks about the time of coincidence. On removing the watch to a distance of twenty-four inches, I found that I lost its ticks during *nine* seconds about the time of coincidence. It is here important to remark that the ticks of the clock are *longer* in duration, as well as *lower* in pitch, than those of the watch's. With the watch remaining at the distance of twenty-four inches from the ear, I listened with all my attention, as tick by tick the watch approached the time of coincidence. Since the ticks of the watch are shorter in duration than those of the clock, they are *overlapped* by the other about the time of coincidence. Hence as, so to speak, the short ticks of the watch glided tick after tick, under the long ticks of the clock, I perceived that more and more of the duration of each successive watch-tick became extinguished by the tick of the clock, until only the *tail* end of the short tick of the watch was left audible and at last even this also crept under the long tick of the clock and the whole of the ticks of the watch were rendered inaudible for *nine* seconds, at the end of which time the front or *head* of the watch-tick, as we may call it, protruded beyond the clock-tick, and then slowly grew up into a complete watch-tick as before. In this succession of events the tick of the old silver watch (made by Tobias) disappears with a sharp *chirp*, like a cricket's, and re-appears with a sound like that made by a boy's marble falling upon others in his pocket. By this experiment, therefore, a gradual analysis is made of the effect of the tick of the clock on the tick of the watch, affording a beautiful illustration of the fact that one sonorous sensation may overcome and obliterate another.

Experiments to determine the relative intensity of the Clock-ticks which obliterate the Watch-ticks.—The clock was placed on a post in the middle of an open level field in the country, on nights when the air was calm and noiseless. The ticks of the clock became just inaudible when my ear was removed to a distance of 350 feet. The ticks of the watch became just inaudible at a distance of twenty feet. The ratio of the squares of these numbers makes the ticks of the clock about 300 times more intense than those of the watch. On the same nights that I made the above determinations I also put the clock on the post and placing against my zygomatic process a slender stick graduated to inches and tenths, I stood with my ear at distances from the clock of from eight to sixteen feet, and then slid the watch above and along the stick (taking care that it did not touch it) until it reached such a distance from the ear that its fifth tick just disappeared. Knowing the relative intensities of the ticks of clock and watch when placed at the same distance

from the ear, the law of the reciprocals of the squares gives the relative intensities when the clock and watch are at the several distances obtained in the above experiments. Large numbers of such experiments have been made, and the results agree perfectly well when we take into consideration first, the difficulty thrown in the path of the determinations by the *gradual* fading away of the watch-ticks as they approach coincidence with the clock-ticks; and, secondly, the impossibility of arriving at *any* result at all, if the slightest noise (the rustle of a gentle breeze, the piping of frogs, the bark of a distant dog) should fall on the ear of the observer when engaged in making an experiment. The general result of the numerous experiments thus made shows that the sensation of the watch-tick is obliterated by a coincident tick of the clock, when the intensity of the clock-tick is *three times* that of the watch-tick. This result, however, must be regarded as merely approximative, not only from the manner in which it was obtained, but from the *complexity* of the sounds on which the experiments were made. It is interesting, however, both as being, I believe, the first determination of this kind that has ever been made, and as having opened out a new and important field of research in physiological acoustics.

Experiments on the Interference of the sensations of Musical Sounds.—Reserving the further development of my discoveries for future papers, I will now briefly describe some of the more prominent and simple phenomena, which I discovered in experimenting with *musical sounds.* At the outset I will remove an objection always made by those versed in acoustics, but unacquainted with these new phenomena. It is as follows:—"You say that one sound may obliterate the sensation of another; but are you sure that the real fact is not an alteration of the *quality* of the more intense sound by the action of the concurrent feebler vibration?" I exclude this objection by experimenting as follows:—An open or closed organ-pipe is sounded forcibly, and at a few feet from it is placed the instrument emitting the sound to be obliterated, which may be either a tuning-fork on its resonance box, or a closed organ-pipe communicating with a separate bellows. Suppose that in the following experiment both tuning-fork and closed organ-pipe produce a note higher in pitch than the more intense or extinguishing sound of the open organ-pipe. Now sound the fork alone strongly, and alternately shut and open its resonance box with the hand. We can thus obtain the sound of the fork in a *regular measure of time.* When the ear has well apprehended the intervals of silence and of sound thus produced, begin the experiment by sounding the open pipe and tuning-fork simultaneously Now, if any change is thus effected in the quality of sound emitted by the open pipe, this change cannot occur except when the fork is sounded, and hence, if it occurs at all,

it must occur in the regular measure in which the fork is sounded. The following are the facts really observed. At first every time that the mouth of the box is open, the sound of the fork is distinctly heard, and changes the quality of the note of the open pipe. But as the vibrations of the fork run down in amplitude, the sensations of its effect become less and less, till they soon entirely vanish, and not the slightest change can be observed in the quality or intensity of the note of the open organ-pipe, whether the resonance box of the fork be open or closed. Indeed at this stage of the experiment the vibrations of the fork may be suddenly and totally stopped without the ear being able to detect the fact. But if instead of stopping the fork when it becomes inaudible, we stop the sound of the open organ-pipe, it is impossible not to feel surprised at the strong sound of the fork which the open pipe had smothered and had rendered powerless to affect the ear. If we replace the tuning-fork by a closed organ-pipe of the same pitch, the results will be the same, but in this case I adjust the intensity of the higher closed pipe to the point of extinction by regulating the flow of air from the bellows by a valve worked with a screw. The alternation of sound and silence is obtained by closing and opening the mouth of the closed pipe by the hand.

2. *On the discovery of the fact that a sound even when intense cannot obliterate the sensation of another sound lower than it in pitch.*

High Sounds cannot obliterate Low Sounds.—A new and remarkable fact was now discovered. No sound, even when very intense, can diminish or obliterate the sensation of a concurrent sound which is lower in pitch. This was proved by experiments similar to the last, but differing in having the more intense sound higher (instead of lower) in pitch. In this case, when the ear decides that the sound of the (lower and feebler) tuning-fork is just extinguished, it is generally discovered on stopping the higher sound, that *the fork*, which should produce the lower sound, *has ceased to vibrate.* This surprising experiment must be made in order to be appreciated. I will only remark that very many similar experiments, ranging through four octaves, have been made, with consonant and dissonant intervals, and that scores of different hearers have confirmed this discovery. It is important to understand that this phenomenon depends solely on *difference* of pitch, and not at all on the absolute pitch of the notes. Thus a feeble c''' (1024 double vibrations) is heard as distinctly through an intense e''' (1280 double vibrations) as a feeble c (128 double vibrations) is heard through an intense g (192 double vibrations) or an intense c' (256 double vibrations).

The development of the applications and of the further illustrations of these discoveries would occupy too much space; I must therefore restrict myself to mentioning some of the most interesting. Let a man read a sentence over and over again with the same tone and modulation of voice, and while he is so doing forcibly sound a c' pipe (256 double vibrations). A remarkable effect is produced, which varies somewhat with the voice experimented on, but the ordinary result is as follows. It appears as though two persons were reading together, one with a grave voice (which is found by the combination of all the reader's real vocal sounds below c in pitch, or having less than 256 double vibrations), the other with a high-pitched voice, generally squeaky and nasal, and, I need not add, very disagreeable. Of course the aspirates come out with a distressing prominence. I have observed many curious illustrations of this change in the quality of the tone of the voice, caused by the entire or partial obliteration of certain vocal components, while listening to persons talking during the sound of a steam whistle, or in one of our long, resonant American railway carriages. Experiments similar to those on the human voice, can be made, with endless modifications, on other composite sounds, as those of reed-pipes, of stringed instruments, of running water, &c. With one of my c (128 double vibrations) free Grenié reeds, I get very marked results. Using as a concurrent sound an intense c' (256 double vibrations) I perceive the prime or fundamental simple tone c to be unaffected in intensity, while all the other partial tones (higher harmonics or overtones, as they are sometimes called) are almost obliterated, except the fifth partial (or fourth upper partial e'', of 640 double vibrations, and the sixth partial (or fifth upper partial) g'' (of 768 double vibrations), which come out with wonderful distinctness. The fact that the lowest, or prime partial tone in the majority of ordinary compound musical tones is strongest, is due (among other reasons) to the fact that the sensation of each partial tone of which the whole musical tone is composed, is diminished by the action on the ear of all the components or partial tones, *below* it in pitch. Thus the higher the pitch of any component or partial tone, the greater the number of lower components which tend to obliterate it. But the prime, or lowest component partial tone, is not affected by any other. Another illustration I cannot resist giving. At the end of the street in New York, in which I resided, there is a large fire-alarm bell, the residual sound of which, after its higher components have disappeared, is a deep simple tone. This bass sound holds its own with total indifference to the clatter of horses, or to any sounds *above* it in pitch. It dies out with a smooth gradient, generally without the slightest indentation or break produced by the other sounds of the street. Indeed, in this case, as in all others where one

sound remains unaffected by intense higher notes, the observer feels as though he had a special sense for the perception of the graver sound—an organ entirely distinct from that which receives the impress of the higher tones.

That one sonorous sensation cannot interfere with another which is lower in pitch, is a remarkable physiological discovery, and next after the demonstration of the fact that the ear is capable of analyzing compound musical sounds into their constituent or partial simple tones, is probably the most important addition yet made to our knowledge of the nature of hearing. It cannot fail to introduce profund modifications into the hypotheses heretofore framed respecting the mechanism and functions of the ear.

3. *On a proposed change in the usual method of conducting Orchestral Music, indicated by the above discoveries.*

We have seen how an intense sound may obliterate, entirely or in part, the sensations of certain partial tones or components of any musical tone, and thus produce a profound change in its quality. In a large orchestra I have repeatedly witnessed the entire obliteration of all sounds from violins, by the deeper and more intense sounds of the wind instruments, the double-bases alone holding their own. I have also observed the sounds of the clarinets lose their peculiar quality of tone and consequent charm from the same cause. No doubt the conductor of the orchestra heard all his violins, ranged as they always are close around him, and did not perceive that his clarinets had lost that quality of tone on which *the composer* had relied for producing a special character of expression.

The function of the conductor of an orchestra seems to be threefold. First, to regulate and fix the time. Secondly, to regulate the intensity of the sounds produced by the individual instruments, for the purpose of expression. Thirdly, to give the proper quality of tone or *feeling* to the whole sound of his orchestra, considered as a single instrument, by regulating *the relative intensities* of the sounds produced by the various classes of instruments employed. Now this third function, the regulation of relative intensities, has hitherto been discharged through the judgment of the ears of a conductor who is placed in the most disadvantageous position for judging by his ears. Surely he is not conducting for his own personal gratification, but for the gratification of his audience, whose ears stand in very different relations from his own in respect to their distance from the various instruments in action. Is it not time that he should pay more attention to his third function and place himself in the position occupied by an average hearer? This position would be elevated, and somewhere in the midst of the audience. The exact determination of its place would depend on various

conditions which cannot now be considered. That the position at present occupied by the conductor of an orchestra has often allowed him to deprive his audience of some of the most delicate and touching qualities of orchestral and concerted vocal music I have no doubt, and I firmly believe that when he changes his position in the manner now proposed the audience will have some of that enjoyment which he has too long kept to himself. During the past winter, in the Academy of Music at New York, and this spring at Offenbach's concerts, I fully confirmed all the foregoing surmises, by placing myself in different parts of the house to observe the different results, and my opinions were fully shared by others who have a more delicate musical organization than I can lay claim to.

In large orchestras, these interferences of sonorous sensations are so multiplied and various as to be beyond our mental conception. By taking them up in detail, some general laws may, however, be evolved. But it will be impossible to formulate such laws until, firstly, we are in possession of a *quantitative* analysis of the compound tones of all musical instruments (that is, until we know the relative loudness of the partial tones of which they are composed at all parts of their compass), and secondly, we have determined throughout the musical scale the relative intensities of the sounds (of simple tones) when obliteration of the sensations of higher (simple) tones supervenes. The powerlessness of one sound to affect the sensation due to another sound lower than itself in pitch greatly simplifies this problem.

4. *Applications of the interferences of sonorous sensations to the determinations of the Relative Intensities of Sounds.*

Quantitative analysis of the compound tones of musical instruments is now the great desideratum of the composer. It is only after we know the relative intensities of the components of typical musical tones used in orchestral performances, that we can so regulate their intensities as to give those qualities of sound which the composer desires to be heard. Thus, it at once becomes evident that the instruments used in orchestral music should be very differently constructed from those used for solos or quartets. In orchestral instruments certain *characteristic* upper partials (overtones, harmonics) should predominate, in order to find expression in the midst of other and graver sounds. Such orchestral instruments will therefore have exaggerated peculiarities in their qualities of tone, which will render them unfit to be played on alone, and uninfluenced by other orchestral notes. It is surely not hopeless to anticipate that empirical rules may be attained, which will guide the musical instrument-maker to the production of those special qualities of tone required in orchestral instruments. It is fortu-

nate that the very phenomena of the interferences of sonorous sensations will assist in the much desired solution of the problem of measuring the intensity of a sound (simple tone), either when existing alone or as component of an ordinary musical (compound) tone. On this subject I am now engaged. It is evident (by way of illustration), that so far as concerns the measure of the relative intensities of sounds *of the same pitch*, this problem has already received the simplest solution by merely placing these sounds at various distances, and obliterating the sensations they excite by means of a constant and standard sound of a lower pitch. But I reserve a description of this work for a more formal publication.

ART. XL.—*Address at the Glasgow Meeting of the British Association;* by Professor SIR WILLIAM THOMSON, President of the Mathematical and Physical Section.

A CONVERSATION which I had with Professor Newcomb one evening last June, in Professor Henry's drawing-room in the Smithsonian Institution, Washington, has forced me to give all my spare thoughts ever since to Hopkins's problem of Precession and Nutation, assuming the earth a rigid spheroidal shell filled with liquid. Six weeks ago, when I landed in England after a most interesting trip to America and back, and became painfully conscious that I must have the honor to address you here to-day, I wished to write an address of which science in America should be the subject. I came home, indeed, vividly impressed with much that I had seen, both in the Great Exhibition of Philadelphia and out of it, showing the truest scientific spirit and devotion, the originality, the inventiveness, the patient persevering thoroughness of work, the appreciativeness, and the generous openmindedness and sympathy, from which the great things of science come.

Θέλω λέγειν Ἀτρεῖδας
Θέλω δὲ Κυδμὸν ᾄδειν.

I wish I could speak to you of the veteran Henry, generous rival of Faraday in electromagnetic discovery; of Peirce the founder of high mathematics in America; of Bache, and of the splendid heritage he has left to America and to the world in the United States Coast Survey; of the great school of astronomers which followed, Gould, Newton, Newcomb, Watson, Young, Alvan Clarke, Rutherfurd, Draper, father and son: of Commander Belknap and his great exploration of the Pacific depths by pianoforte wire, with imperfect apparatus supplied from Glasgow, out of which he forced a success in his own way; of Cap-

tain Sigsbee, who followed with like fervor and resolution, and made further improvements in the apparatus by which he has done marvels of easy, quick, and sure deep-sea sounding in his little surveying ship *Blake;* and of the admirable official spirit which makes such men and such doings possible in the United States Naval Service. I would like to tell you too of my reason for confidently expecting that American hydrography will soon supply the data from tidal observations, long ago asked of our Government in vain by a Committee of the British Association, by which the amount of the earth's elastic yielding to the distorting influence of the sun and moon will be measured; and of my strong hope that the Compass Department of the American Navy will repay the debt to France, England, and Germany so appreciatively acknowledged in their reprint of the works of Poisson, Airy, Archibald Smith, Evans, and the Liverpool Compass Committee, by giving in return a fresh marine survey of terrestrial magnetism, to supply the navigator with data for correcting his compass without sights of sun or stars.

Can I go on to precession and nutation without a word of what I saw in the Great Exhibition of Philadelphia? In the U. S. Government part of it, Professor Hilgard showed me the measuring-rods of the U. S. Coast Survey, with their beautiful mechanical appliances for end measurement, by which the three great base lines of Maine, Long Island, and Georgia, were measured with about the same accuracy as the most accurate scientific measurers, whether of Europe or America, have attained in comparing two meter or yard measures.

In the United States telegraphic department I saw and heard Elisha Gray's splendidly worked-out electric telephone actually sounding four messages simultaneously on the Morse code, and clearly capable of doing yet four times as many with very moderate improvements of detail; and I saw Edison's automatic telegraph delivering 1,015 words in 57 seconds: this done by the long-neglected electro-chemical method of Bain, long ago condemned in England to the helot work of recording from a relay, and then turned adrift as needlessly delicate for that. In the Canadian department I heard "To be or not to be, ... there's the rub," through an electric telegraph wire; but, scorning monosyllables, the electric articulation rose to higher flights, and gave me passages taken at random from the New York newspapers:—"S. S. Cox has arrived" (I failed to make out the S. S. Cox); "The City of New York," "Senator Morton," "The Senate has resolved to print a thousand extra copies;" "The Americans in London have resolved to celebrate the coming Fourth of July." All this my own ears heard, spoken to me with unmistakable distinctness by the thin circular disc armature of just such another little electro-magnet as this which

I hold in my hand. The words were shouted with a clear and loud voice by my colleague-judge, Professor Watson, at the far end of the telegraph wire, holding his mouth close to a stretched membrane, such as you see before you here, carrying a little piece of soft iron, which was thus made to perform in the neighborhood of an electro-magnet in circuit with the line motions proportional to the sonorific motions of the air. This, the greatest by far of all the marvels of the electric telegraph, is due to a young countryman of our own, Mr. Graham Bell, of Edinburgh and Montreal, and Boston, now becoming a naturalized citizen of the United States. Who can but admire the hardihood of invention which devised such very slight means to realize the mathematical conception that, if electricity is to convey all the delicacies of quality which distinguish articulate speech, the strength of its current must vary continuously and as nearly as may be in simple proportion to the velocity of a particle of air engaged in constituting the sound?

The Patent Museum of Washington, an institution of which the nation is justly proud, and the beneficent working of the United States patent laws, deserve notice in the section of the British Association concerned with branches of science to which nine-tenths of all the useful patents of the world owe their foundations. I was much struck with the prevalence of patented inventions in the Exhibition: it seemed to me that every good thing deserving a patent was patented. I asked one inventor of a very good invention "Why don't you patent it in England?" He answered, "The conditions in England are too onerous." We certainly are far behind America's wisdom in this respect. If Europe does not amend its patent laws (England in the opposite direction to that proposed in the Bills before the last two sessions of Parliament) America will speedily become the nursery of useful inventions for the world.

I should tell you also of "Old Prob's" weather warnings, which cost the nation 250,000 dollars a year; money well spent say the western farmers, and not they alone: in this the whole people of the United States are agreed, and though Democrats or Republicans playing the "economical ticket" may for half a session stop the appropriations for even the United States Coast Survey, no one would for a moment think of proposing to starve "Old Prob;" and now that 80 per cent of his probabilities have proved true, and General Myers has for a month back ceased to call his daily forecasts "probabilities" and has begun to call them indications, what will the western farmers call him this time next year?

And the United States Naval Observatory, full of the very highest science, under the command of Admiral Davis! If, to get on to precession and nutation, I had resolved to omit

telling you that I had there, in an instrument for measuring photographs of the transit of Venus—shown me by Professor Harkness, a young Scotsman attracted into the United States Naval Service—seen for the first time in an astronomical observatory a geometrical slide, the verdict on the disaster on board the *Thunderer*, published while I am writing this address, forbids me to keep any such resolution, and compels me to put the question, Is there in the British Navy, or in a British steamer, or in a British land boiler another safety-valve so constructed that by any possibility, at any temperature, or under any stress it can jam? and to say that if there is it must be instantly corrected or removed.

I ought to speak to you, too, of the already venerable Harvard University, the Cambridge of America, and of the Technological Institute of Boston, created by William Rogers, brother of my late colleague in this university (Glasgow), Henry Rogers, and of the Johns Hopkins University of Baltimore, which with its youthful vigor has torn Sylvester from us, has utilised the genius and working power of Rowland for experimental research, and three days after my arrival in America, sent for the young Porter Poinier to make him a Fellow. But he was on his death-bed in New York "begging his physicians to keep him alive just to finish his book, and then he would be willing to go." Of his book, "Thermodynamics," we may hope to see at least a part, for much of the manuscript, and good and able friends to edit it, are left; but the appointment to a Fellowship in the Johns Hopkins University came a day too late to gratify his noble ambition.

But the stimulus of intercourse with American scientific men left no place in my mind for framing, or attempting to frame a report on American science. Disturbed by Newcomb's suspicions of the earth's irregularities as a Time-keeper, I could think of nothing but precession and nutation, and tides and monsoons, and settlements of the equatorial regions, and melting of polar ice. Week after week passed before I could put down two words which I could read to you here to-day: and so I have nothing to offer you for my Address but—

Review of Evidence regarding the Physical Condition of the Earth; its Internal Temperature; the Fluidity or Solidity of its Interior Substance; the Rigidity, Elasticity, Plasticity, of its External Figure; and the Permanence or Variability of its Period and Axis of Rotation.

The evidence of a high internal temperature is too well known to need any quotation of particulars at present. Suffice it to say that below the uppermost ten meters stratum of rock or soil sensibly affected by diurnal and annual variations of tem-

perature, there is generally found a gradual increase of temperature downward, approximating roughly, in ordinary localities, to an average rate of 1° C. per thirty meters of descent, but much greater in the neighborhood of active volcanoes, and certain other special localities of comparatively small area, where hot springs and, perhaps, also, sulphurous vapors prove an intimate relationship to volcanic quality. It is worthy of remark in passing, that, so far as we know at present, there are no localities of exceptionally *small* rate of augmentation of underground temperature, and none where temperature diminishes at any time through any considerable depth downward below the stratum sensibly influenced by summer heat and winter cold. Any considerable area of the earth of, say, not less than a kilometer in any horizontal diameter, which for several thousand years had been covered by snow or ice, and from which the ice had melted away and left an average surface temperature of 13°, would, during nine hundred years, show a decreasing temperature for some depth down from the surface: and thirty-six hundred years after the clearing away of the ice would still show a residual effect of the ancient cold, in a half rate of augmentation of temperature downward in the upper strata, gradually increasing to the whole normal rate which would be sensibly reached at a depth of 600 meters.

By a simple effort of geological calculus it has been estimated that 1° per 30 meters gives 1000° per 30,000 meters, and 3333° per 100 kilometers. This arithmetical result is irrefragable, but what of the physical conclusion drawn from it with marvellous frequency and pertinacity that at depths of from 30 to 100 kilometers the temperatures are so high as to melt all substances composing the earth's upper crust? It has been remarked, indeed, that if observation showed any diminution or augmentation of the rate of increase of undergroud temperature in great depths, it would not be right to reckon on the uniform rate of 1° per 30 meters, or thereabouts, down to 30 or 60 or 100 kilometers. "But observation has shown nothing of the kind, and therefore surely it is most consonant with inductive philosophy to admit no great deviation in any part of the earth's solid crust from the rate of increase proved by observation as far as the greatest depths to which we have reached!" Now I have to remark upon this argument that the greatest depth to which we have reached in observations of underground temperature is scarcely one kilometer; and that, if a 10 per cent diminution of the rate of augmentation of underground temperature downward were found at a depth of one kilometer, this would demonstrate* that within the last 100,000 years the

*** For proof of this and following statements regarding Underground Heat I refer to "Secular Cooling of the Earth," *Transactions* of the Royal Society of Edinburgh, 1862, and Thomson and Tait's "Natural Philosophy," Appendix D.**

upper surface of the earth must have been at a higher temperature than that now found at the depth of one kilometer. Such a result is no doubt to be found by observation in places which have been overflown by lava in the memory of man, or a few thousand years farther back; but if, without going deeper than a kilometer, a 10 per cent diminution of the rate of increase of temperature downward were found for the whole earth, it would limit the whole of geological history to within 100,000 years, or, at all events, would interpose an absolute barrier against the continuous descent of life on the earth from earlier periods than 100,000 years ago. Therefore, although search in particular localities for a diminution of the rate of augmentation of underground temperature in depths of less than a kilometer may be of intense interest, as helping us to fix the dates of extinct volcanic actions which have taken place within 100,000 years or so, we know enough from thoroughly sure geological evidence not to expect to find it, except in particular localities, and to feel quite sure that we shall not find it under any considerable portion of the earth's surface. If we admit as possible any such discontinuity within 900,000 years, we might be prepared to find a sensible diminution of the rate at three kilometers depth; but not at anything less than 30 kilometers if geologists validly claim as much as 90,000,000 of years for the length of the time with which their science is concerned. Now this implies a temperature of 1000° C. at the depth of 30 kilometers, allows something less than 2000° for the temperature at 60 kilometers, and does not require much more than 4000° C. at any depth, however great; but does require at the great depths a temperature of at all events not less than about 4000° C. It would not take much "hurrying up" of the actions with which they are concerned, to satisfy geologists with the more moderate estimate of 50,000,000 of years. This would imply at least about 3000° C. for the limiting temperature at great depths. If the actual substance of the earth, whatever it may be, rocky or metallic, at depths of from 60 to 100 kilometers, under the pressure actually there experienced by it can be solid at temperatures of from 3000° to 4000°, then we may hold the former estimate (90,000,000) to be as probable as the latter (50,000,000) so far as evidence from underground temperature can guide us. If 4000° would melt the earth's substance at a depth of 100 kilometers, we must reject the former estimate, though we might still admit the latter; if 3000° would melt the substance at a depth of 60 kilometers, we should be compelled to conclude that 50,000,000 of years is an over-estimate. Whatever may be its age, we may be quite sure the earth is solid in its interior; not, I admit, throughout its whole volume, for there certainly are spaces in

volcanic regions occupied by liquid lava: but whatever portion of the whole mass is liquid, whether the waters of the ocean or melted matter in the interior, these portions are small in comparison with the whole, and we must utterly reject any geological hypothesis which, whether for explaining underground heat or ancient upheavals and subsidences of the solid crust, or earthquakes, or existing volcanoes, assumes the solid earth to be a shell of 30, or 100, or 500, or 1,000 kilometers thickness, resting on an interior liquid mass.

This conclusion was first arrived at by Hopkins, who may therefore properly be called the discoverer of the earth's solidity. He was led to it by a consideration of the phenomena of precession and nutation, and gave it as shown to be highly probable, if not absolutely demonstrated, by his confessedly imperfect and tentative investigation. But a rigorous application of the perfect hydrodynamical equations leads still more decidedly to the same conclusion.

I am able to say this to you now in consequence of the conversation with Professor Newcomb to which I have already alluded. Admitting fully my evidence for the rigidity of the earth from the tides, he doubted the argument from precession and nutation. Trying to recollect what I had written on it fourteen years ago in a paper on the Rigidity of the Earth, published in the *Transactions* of the Royal Society, my conscience smote me, and I could only stammer out that I had convinced myself that so and so, and so and so, at which I had arrived by a non-mathematical short cut, were true. He hinted that viscosity might suffice to render precession and nutation the same as if the earth were rigid, and so vitiate the argument for rigidity. This I could not for a moment admit any more than when it was first put forward by Delaunay. But doubt entered my mind regarding the so and so, and so and so; and I had not completed the night journey to Philadelphia which hurried me away from our unfinished discussion before I had convinced myself that they were grievously wrong. So now I must request as a favor that each one of you on going home will instantly turn up his or her copies of the *Transactions* of the Royal Society for 1862, and of Thomson and Tait's "Natural Philosophy," vol. i., and draw the pen through §§ 23–31 of my paper on the "Rigidity of the Earth" in the former, and through everything in §§ 847–849 of the latter, which refers to the effect on precession and nutation of an elastic yielding of the earth's surface.

When those passages were written I knew little or nothing of vortex motion; and until my attention was recalled to them by Professor Newcomb, I had never once thought of this subject in the light thrown upon it by the theory of the quasi-rigidity

induced in a liquid by vortex motion which has of late occupied me so much. With this fresh light a little consideration sufficed to show me that (although the old obvious conclusion is of course true, that if the inner boundary of the imagined rigid shell of the earth were rigorously spherical, the interior liquid could experience no precessional or nutational influence from the pressure on its bounding surface, and therefore if homogeneous could have no precession or nutation at all, or if heterogeneous only as much precession and nutation as would be produced by attraction from without in virtue of non-sphericity of its surfaces of equal density, and therefore the shell would have enormously more rapid precession and nutation than it actually has—forty times as much, for instance, if the thickness of the shell is sixty kilometers) a very slight deviation of the inner surface of the shell from perfect sphericity would suffice, in virtue of the quasi-rigidity due to vortex motion, to hold back the shell from taking sensibly more precession than it would give to the liquid, and to cause the liquid (homogeneous or heterogeneous) and the shell to have sensibly the same precessional motion as if the whole constituted one rigid body. But it is only because of the very long period (26,000 years) of precession, in comparison with the period of rotation (one day), that a very slight deviation from sphericity would suffice to cause the whole to move as if it were a rigid body. A little further consideration showed me—

(1) That an ellipticity of inner surface equal to $\frac{1}{26000 \times 365}$ would be too small, but that an ellipticity of one or two hundred times this amount would not be too small, to compel approximate equality of precession throughout liquid and shell.

(2) That with an ellipticity of interior surface equal to $\frac{1}{300}$, if the precessional motive were 26,000 times as great as it is, the motion of the liquid would be very different from that of a rigid mass rigidly connected with the shell:

(3) That with the actual forces and the supposed interior ellipticity of $\frac{1}{300}$ the lunar nineteen-yearly nutation might be affected to about five per cent of its amount by interior liquidity.

(4) Lastly, that the lunar semi-annual nutation must be largely, and the lunar fortnightly nutation enormously, affected by interior liquidity.

But although so much could be foreseen readily enough, I found it impossible to discover, without thorough mathematical investigation, what might be the characters and amounts of the deviations from a rigid body's motion which the several cases of precession and nutation contemplated would present. The investigation, limited to the case of a homogeneous liquid en-

closed in an ellipsoidal shell, has brought out results which I confess have greatly surprised me. When the interior ellipticity of the shell is just too small, or the periodic speed of the disturbance just too great to allow the motion of the whole to be sensibly that of a rigid body, the deviation first sensible renders the precessional or nutational motion of the shell smaller than if the whole were rigid, instead of greater, as I expected. The amount of this difference bears the same proportion to the actual precession or nutation as the fraction measuring the periodic speed of the disturbance (in terms of the period of rotation as unity) bears to the fraction measuring the interior ellipticity of the shell; and it is remarkable that this result is independent of the thickness of the shell, assumed however to be small in proportion to the earth's radius. Thus in the case of precession the effect of interior liquidity would be to diminish the periodic speed of the precession in the proportion stated; in other words, it would add to the precessional period a number of days equal to the multiple of the rotational period equal to the number whose reciprocal measures the ellipticity. Thus in the actual case of the earth if we still take $\frac{1}{300}$ as the ellipticity of the inner boundary of the supposed rigid shell, the effect would be to augment by 300 days the precessional period of 2,600 years, or to diminish by about $\frac{1}{60}''$ the annual precession of about 51″—an effect which I need not say would be wholly insensible. But on the lunar nutation of 18·6 years period the effect of interior liquidity would be quite sensible; 18·6 years being 23 times 300 days, the effect would be to diminish the axes of the ellipse which the earth's pole describes in this period each by $\frac{1}{23}$ of its own amount. The semi-axes of this ellipse calculated on the theory of perfect rigidity from the very accurately known amount of precession and the fairly accurate knowledge which we have of the ratio of the lunar to the solar part of the precessional motive are 9″·22 and 6″·86, with an uncertainty not amounting to one-half per cent on account of want of perfect accuracy in the latter part of data. If the true values were less each by $\frac{1}{23}$ of its own amount, the discrepance might have escaped detection, or might *not* have escaped detection; but certainly could be found if looked for. So far nothing can be considered as absolutely proved with reference to the interior solidity of the earth from precession and nutation; but now think of the solar semi-annual and the lunar fortnightly nutations. The period of each of these is less than 300 days. Now the hydrodynamical theory shows that irrespective of the thickness of the shell, the nutation of the crust would be zero if the period of the nutational disturbance were 300 times the period of rotation (the ellipticity being $\frac{1}{300}$): if the nutational period were anything between

this and a certain smaller critical value depending on the thickness of the crust, the nutation would be negative; if the period were equal to this second critical value, the nutation would be infinite: and if the period were still less, the nutation would be again positive. Further, the 183 days period of the solar nutation falls so little short of the critical 300 days, that the amount of the nutation is not sensibly influenced by the thickness of the crust—is negative and equal in absolute value to $\frac{61}{39}$ (being the reciprocal of $\frac{300}{183}-1$) times what the amount would be were the earth solid throughout. Now this amount as calculated in the Nautical Almanac makes $0''\cdot55$, and $0''\cdot51$ the semi-axes of the ellipse traced by the earth's axis round its mean position; and if the true nutation placed the earth's axis on the opposite side of an ellipse having $''\cdot86$ and $''\cdot81$ for its semi-axes, the discrepance could not possibly have escaped detection. But lastly, think of the lunar fortnightly nutation. Its period is $\frac{1}{20}$ of 300 days, and its amount, calculated in the Nautical Almanac on the theory of complete solidity, is such that the greater semi-axis of the approximately circular ellipse described by the pole is $0''\cdot0325$. Were the crust infinitely thin this nutation would be negative, but its amount nineteen times that corresponding to solidity. This would make the greater semi-axis of the approximately circular ellipse described by the pole amount to $19\times0''\cdot0885$, which is $1''\cdot7$. It would be negative and of some amount between $1''\cdot7$ and infinity, if the thickness of the crust were anything from zero to 120 kilometers. This conclusion is absolutely decisive against the geological hypothesis of a thin rigid shell full of liquid.

But interesting in a dynamical point of view as Hopkin's problem is, it cannot afford a decisive argument against the earth's interior liquidity. It assumes the crust to be perfectly stiff and unyielding in its figure. This of course it cannot be, because no material is infinitely rigid; but, composed of rock and possibly of continuous metal in the great depths, may the crust not as a whole be still enough to practically fulfill the condition of unyieldingness? No; decidedly it could not; on the contrary, were it of continuous steel and 500 kilometers thick, it would yield very nearly as much as if it were india-rubber, to the deforming influences of centrifugal force and of the sun's and moon's attractions. Now, although the full problem of precession and nutation, and what is now necessarily included in it, tides—in a continuous revolving liquid spheroid, whether homogeneous or heterogeneous, has not yet been coherently worked out, I think I see far enough towards a complete solution to say that precession and nutations will be practically the same in it as in a solid globe, and that the tides will be practically the same as those of the equilibrium

theory. From this it follows that precession and nutations of the solid crust, with the practically perfect flexibility which it would have even though it were 100 kilometers thick and as stiff as steel, would be sensibly the same as if the whole earth from surface to center were solid and perfectly stiff. Hence precession and nutations yield nothing to be said against such hypotheses as that of Darwin,* that the earth as a whole takes approximately the figure due to gravity and centrifugal force, because of the fluidity of the interior and the flexibility of the crust. But alas for this "attractive sensational idea that a molten interior to the globe underlies a thin superficial crust; its surface agitated by tidal waves and flowing freely towards any issue that may here and there be opened for its outward escape," as Poulett Scrope called it! the solid crust would yield so freely to the deforming influence of sun and moon that it would simply carry the waters of the ocean up and down with it, and there would be no sensible tidal rise and fall of water relatively to land.

The state of the case is shortly this:—The hypothesis of a perfectly rigid crust containing liquid violates physics by assuming preternaturally rigid matter and violates dynamical astronomy in the solar semi-annual and lunar fortnightly nutations; but tidal theory has nothing to say against it. On the other hand the tides decide against any crust flexible enough to perform the nutations correctly with a liquid interior, or as flexible as the crust must be unless of preternaturally rigid matter.

But now thrice to slay the slain; suppose the earth this moment to be a thin crust of rock or metal resting on liquid matter. Its equilibrium would be unstable! And what of the upheavals and subsidences? They would be strikingly analogous to those of a ship which has been rammed: one portion of crust up and another down, and then all down. I may say with almost perfect certainty, that, whatever may be the relative densities of rock, solid and melted, at or about the temperature of liquifaction, it is, I think, quite certain that cold solid rock is denser than hot melted rock: and no possible degree of rigidity in the crust could prevent it from breaking in pieces and sinking wholly below the liquid lava. Something like this may have gone on and probably did go on for thousands of years after solidification commenced; surface portions of the melted material losing heat, freezing, sinking immediately, or growing to thicknesses of a few meters when the surface would be cool and the whole solid dense enough to sink. "This

* "Observations on the Parallel Roads of Glen Roy and other Parts of Lochaber in Scotland, with an attempt to prove that they are of Marine Origin."—*Transactions* of the Royal Society for Feb., 1839, p. 81.

process must go on until the sunk portions of crust build up from the bottom a sufficiently close-ribbed skeleton or frame, to allow fresh incrustations to remain bridging across the now small areas of lava, pools or lakes.

"In the honey-combed solid and liquid mass thus formed, there must be a continual tendency for the liquid, in consequence of its less specific gravity, to work its way up; whether by masses of solid falling from the roofs of vesicles or tunnels, and causing earthquake shocks, or by the roof breaking quite through when very thin, so as to cause two such hollows to unite or the liquid of any of them to flow out freely over the outer surface of the earth; or by gradual subsidence of the solid owing to the thermodynamic melting, which portions of it under intense stress must experience according to my brother's theory. The results which must follow from this tendency seem sufficiently great and various to account for all that we learn from geological evidence of earthquakes, of upheavals and subsidences of solid, and of eruptions of melted rock."*

Leaving altogether now the hypothesis of a hollow shell filled with liquid, we must still face the question, how much does the earth, solid throughout, except small cavities or vesicles filled with liquid, yield to the deforming (or tide-generating) influences of sun and moon? This question can only be answered by observation. A single infinitely accurate spirit-level or plummet far enough away from the sea to be not sensibly affected by the attraction of the rising and falling water would enable us to find the answer. Observe by level or plummet the changes of direction of apparent gravity relatively to an object rigidly connected with the earth, and compare these changes with what they would be were the earth perfectly rigid, according to the known masses and distances of sun and moon. The discrepance, if any is found, would show distortion of the earth and would afford data for determining the dimensions of the elliptic spheroid into which a non-rotating globular mass of the same dimensions and elasticity as the earth would be distorted by centrifugal force if set in rotation, or by the tide-generating influence of sun or moon. The effect on the plumb-line of the lunar tide-generating influence is to deflect it towards or from the point of the horizon nearest to the moon, according as the moon is above or below the horizon. The effect is zero when the moon is on the horizon or overhead, and is greatest in either direction when the moon is 45° above or below the horizon. When this greatest value is reached, the plummet is drawn from its mean position through

* **"Secular Cooling of the Earth."** ***Transactions*** **of the Royal Society of Edinburgh, 1862 (W. Thomson), and Thomson and Tait's "Natural Philosophy,"** §§ *(e e)*, *(f f)*.

a space equal to $\frac{1}{12000000}$ of the length of the thread. No ordinary plummet or spirit-level could give any perceptible indication whatever of this effect; and to measure its amount it would be necessary to be able to observe angles as small as $\frac{1}{120000000}$ of the radius, or about $\frac{1}{600}''$. Siemens' beautiful hydrostatical multiplying level may probably supply the means for doing this. Otherwise at present no apparatus exists within small compass by which it could be done. A submerged water-pipe of considerable length, say twelve kilometers, with its two ends turned up and open might answer. Suppose, for example, the tube to lie North and South, and its two ends to open into two small cisterns, one of them, the southern, for example, of half a decimeter diameter (to escape disturbance from capillary attraction); and the other of two or three decimeters diameter (so as to throw nearly the whole rise and fall into the smaller cistern). For simplicity suppose the time of observation to be when the moon's declination is zero. The water in the smaller or southern cistern will rise from its lowest position to its highest position while the moon is rising to maximum altitude, and fall again after the moon crosses the meridian till she sets: and it will rise and fall again through the same range from moonset to moonrise. If the earth were perfectly rigid, and if the locality were in latitude 45°, the rise and fall would be half a millimeter on each side of the mean level; or a little short of half a millimeter if the place is within 10° north or south of latitude 45°. If the air were so absolutely quiescent during the observations as to give no varying differential pressure on the two water surfaces to the amount of $\frac{1}{100}$ millimetre of water, or $\frac{1}{1400}$ of mercury, the observation would be satisfactorily practicable, as it would not be difficult by aid of a microscope to observe the rise and fall of the water in the smaller cistern to $\frac{1}{100}$ of a millimeter; but no such quiescence of the atmosphere could be expected at any time, and it is probable that the variations of the water-level due to difference of the barometric pressure at the two ends would in all ordinary weather quite overpower the small effect of the lunar tide-generating motive. If, however, the two cisterns instead of being open to the atmosphere were connected air-tightly by a return pipe with no water in it, it is probable that the observation might be successfully made: but Siemens' level or some other apparatus on similarly small scale would probably be preferable to any elaborate method of obtaining the result by aid of very long pipes laid in the ground; and I have only called your attention to such an ideal method as leading up to the natural phenomenon of tides.

Tides in an open canal or lake of twelve kilometers length would be of just the amount which we have estimated for the cisterns connected by submerged pipe; but would be enor-

mously more disturbed by wind and variations of atmospheric pressure. A canal or lake of 240 kilometers length, in a proper direction in a suitable locality, would give but ten millimeters rise and fall at each end, an effect which might probably be analyzed out of the much greater disturbance produced by wind and differences of barometric pressure; but no open liquid level short of the *ingens æquor*, the ocean, will probably be found so well adapted as it for measuring the absolute value of the disturbance produced on terrestrial gravity by the lunar and solar tide-generating motive. But observations of the diurnal and semi-diurnal tides in the ocean, do not (as they would on smaller and quicker levels) suffice for this purpose, because their amounts differ enormously from the equilibrium values on account of the smallness of their periods in comparison with the periods of any of the grave enough modes of free vibration of the ocean as a whole. On the other hand the lunar fortnightly declinational and the lunar monthly elliptic and the solar semi-annual and annual elliptic tides have their periods so long that their amounts must certainly be very approximately equal to the equilibrium values.

But there are large annual and semi-annual changes of sea-level, probably both differential on account of wind and differences of barometric pressure and differences of temperature of the water, and absolute depending on rain-fall and the melting away of snow and return evaporation, which altogether swamp the small semi-annual and annual tides due to the sun's attraction. Happily, however, for our object there is no meteorological or other disturbing cause which produces periodic changes of sea-level in either the fortnightly declinational or the monthly elliptic period; and the lunar gravitational tides in these periods are therefore to be carefully investigated in order that we may obtain the answer to the interesting question, how much does the earth as an elastic spheroid yield to the tide-generating influence of sun or moon? Hitherto in the British Association Committee's reductions of Tidal Observations we have not succeeded in obtaining any trustworthy indications of either of these tides. The St. George's pier landing-stage pontoon was unhappily chosen, for the Liverpool tide gauge cannot be trusted for so delicate an investigation; the available funds for calculation were expended before the long-period tides for Helbre Island could be attacked, and three years of Kurrachee gave our only approach to a result. Comparisons of this, with an indication of a result with calculations on West Hartlepool tides, conducted with the assistance of a grant from the Royal Society, seem to show possibly no sensible yielding, or perhaps, more probably some degree of yielding, of the earth's figure. The absence from all the results of any indication of a 18·6

yearly tide (according to the same law as the other long-period tides) is not easily explained without assuming or admitting a considerable degree of yielding.

Closely connected with the question of the earth's rigidity, and of as great scientific interest and even of greater practical moment, is the question—how nearly accurate is the earth as a time-keeper? and another of, at all events, equal scientific interest—how about the permanence of the earth's axis of rotation?

Peters and Maxwell, about thirty-five and twenty-five years ago, separately raised the question, how much does the earth's axis of rotation deviate from being a principal axis of inertia? and pointed out that an answer to this question is to be obtained by looking for a variation in latitude of any or every place on the earth's surface in a period of 306 days. The model before you illustrates the travelling round of the instantaneous axis relatively to the earth in an approximately circular cone whose axis is the principal axis of inertia, and relatively to space in a cone round a fixed axis. In the model, the former of these cones, fixed relatively to the earth, rolls internally on the latter, supposed to be fixed in space. Peters gave a minute investigation of observations at Pulkova in the years 1841–42, which seemed to indicate at that time a deviation amounting to about $\frac{3}{40}''$ of the axis of rotation from the principal axis. Maxwell, from Greenwich observations of the years 1851–1854, found seeming indications of a very slight deviation—something less than half a second—but differing altogether in phase from that which the deviation indicated by Peters, if real and permanent, would have produced at Maxwell's later time. On my begging Prof. Newcomb to take up the subject, he kindly did so at once, and undertook to analyze a series of observations suitable for the purpose, which had been made in the United States Naval Observatory, Washington. A few weeks later I received from him a letter referring me to a paper by Dr. Nysen, of Pulkova Observatory, in which a similar negative conclusion as to constancy of magnitude or direction in the deviation sought for is arrived at from several series of the Pulkova observations between the years 1842 and 1872, and containing the following statement of his conclusions:—

"The investigation of the ten month period of latitude from the Washington prime vertical observations from 1862 to 1867 is completed, indicating a coefficient too small to be measured with certainty. The declinations with this instrument are subject to an annual period which made it necessary to discuss those of each month separately. As the series extended through a full five years, each month thus fell on five nearly equidistant

points of the period. If x and y represent the co-ordinates of the axis of instantaneous rotation on June 30, 1864, then the observations of the separate months gave the following values of x and y:—

	x $''$		Weight.		y $''$	Weight.
January ..	− 0·35	...	10	...	+ 0·32	
February ..	− 0·03	...	14	...	+ 0·09	
March ..	+ 0·17	...	10	...	+ 0·16	
April	+ 0·44	...	5	...	+ 0·05	
May	+ 0·08	...	16	...	+ 0·02	
June	− 0·01	...	14	...	− 0·01	
July	− 0·05	...	14	...	− 0·00	
August ..	− 0·24	...	14	...	+ 0·29	
September ..	+ 0·18	...	14	...	+ 0·21	
October ..	+ 0·13	...	14	...	− 0·01	
November ..	+ 0·08	...	17	...	− 0·20	
December ..	− 0·08	...	16	...	− 0·08	
Mean	$0''\cdot01 \pm ''\cdot03$				$+ 0''\cdot05 \pm ''\cdot03$	

Accepting these results as real they would indicate a radius of rotation of the instantaneous axis amounting, at the earth's surface, to 5 feet and a longitude of the point in which this axis intersects the earth's surface near the north pole such that on July 11, 1864, it was 180° from Washington, or 103° east of Greenwich. The excess of the co-efficient over its probable error is so slight that this result cannot be accepted as anything more than a consequence of the unavoidable errors of observation."

From the discordant character of these results we must not, however, infer that the deviations indicated by Peters, Maxwell, and Newcomb are unreal. On the contrary, any that fall within the limits of probable error of the observations ought properly to be regarded as real. There is in fact a *vera causa* in the temporary changes of sea-level due to meteorological causes, chiefly winds, and to meltings of ice in the polar regions and return evaporations, which seems amply sufficient to account for irregular deviations of from $\frac{1}{2}''$ to $\frac{1}{20}''$ of the earth's instantaneous axis from the axis of maximum inertia, or, as I ought rather to say, of the axis of maximum inertia from the instantaneous axis.

As for geological upheavals and subsidences, if on a very large scale of area, they must produce, on the period and axis of the earth's rotation, effects comparable with those produced by changes of sea-level equal to them in vertical amount. For simplicity, calculating as if the earth were of equal density throughout, I find that an upheaval of all the earth's surface in

north latitude and east longitude, and south latitude and west longitude, with equal depressions in the other two quarters, amounting at greatest to 10 centimeters, and graduating regularly from the points of maximum elevation to the points of maximum depression in the middles of the four quarters, would shift the earth's axis of maximum moment of inertia through 1″ on the north side towards the meridian of 90° W. longitude, and on the south side towards the meridian of 90° E. longitude. If such a change were to take place suddenly, the earth's instantaneous axis would experience a sudden shifting of but $\frac{1}{360}$″ (which we may neglect) and then, relatively to the earth, would commence traveling, in a period of 306 days, round the fresh axis of maximum moment of inertia. The sea would be set into vibration, one ocean up and another down through a few centimeters, like water in a bath set aswing. The period of these vibrations would be from twelve to twenty-four hours, or at most a day or two; their subsidence would probably be so rapid that after at most a few months they would become insensible. Then a regular 306 days' period tide of 11 centimeters from lowest to highest would be to be observed, with gradually diminishing amount from century to century, as though the dissipation of energy produced by this tide, the instantaneous axis of the earth is gradually brought into coincidence with the fresh axis of maximum moment of inertia. If we multiply these figures by 3,600, we find what would be the result of a similar sudden upheaval and subsidence of the earth to the extent of 360 meters above and below previous levels. It is not impossible that in the very early ages of geological history such an action as this, and the consequent 400 meters tide producing a succession of deluges every 306 days for many years may have taken place; but it seems more probable that even in the most ancient times of geological history the great world-wide changes, such as the upheavals of the continents and subsidences of the ocean beds from the general level of their supposed molten origin, took place gradually through the thermodynamic melting of solids and the squeezing out of liquid lava from the interior to which I have already referred. A slow distortion of the earth as a whole would never produce any great angular separation between the instantaneous axis and axis of maximum moment of inertia for the time being. Considering, then, the great facts of the Himalayas and Andes, and Africa and the depths of the Atlantic, and America and the depths of the Pacific, and Australia, and considering further the ellipticity of the equatorial section of the sea-level estimated by Capt. Clarke at about $\frac{1}{10}$ of the mean ellipticity of meridianal sections of the sea-level, we need no brush from the comet's tail, a wholly chimerical cause which can never have

been put forward seriously except in ignorance of elementary dynamical principles, to account for a change in the earth's axis; we need no violent convulsion producing a sudden distortion on a great scale with change of the axis of maximum moment of inertia followed by gigantic deluges; and we may not merely admit, but assert as highly probable, that the axis of maximum inertia and axis of rotation, always very near one another, may have been in ancient times very far from their present geographical position, and may have gradually shifted through ten, twenty, thirty, forty, or more degrees without, at any time, any perceptible sudden disturbance of either land or water.

Lastly, as to variations in the earth's rotational period:—You all, no doubt, know how in 1853 Adams discovered a correction to be needed in the theoretical calculation with which Laplace followed up his brilliant discovery of the dynamical explanation of an apparent acceleration of the moon's mean motion, shown by records of ancient eclipses; and how he found that when his correction was applied, the dynamical theory of the moon's motion accounted for only about half of the observed apparent acceleration; and how Delauney in 1866 verified Adams's result, and suggested that the explanation may be a retardation of the earth's rotation by tidal friction. The conclusion is that since March 19, 721 B. C., a day on which an eclipse of the moon was seen in Babylon, commencing "when one hour after her rising was fully passed," the earth has lost rather more than $\frac{1}{3606000}$ of her rotational velocity, or as a timekeeper, is going slower by $11\frac{1}{2}$ seconds per annum now than then. According to this rate of retardation, if uniform, the earth at the end of a century would, as a timekeeper, be found 22 seconds behind a perfect clock, rated and set to agree with her at the beginning of the century. Newcomb's subsequent investigations in the lunar theory have on the whole tended to confirm this result, but they have also brought to light some remarkable apparent irregularities in the moon's motion, which, if real, refuse to be accounted for by the gravitational theory without the influence of some unseen body or bodies passing near enough to the moon to influence her mean motion. This hypothesis Newcomb considers not so probable as that the apparent irregularities of the moon are not real and are to be accounted for by irregularities in the earth's rotational velocity. If this is the true explanation it seems that the earth was going slow from 1850 to 1862, so much as to have got behind 7 seconds in these 12 years, and then to have begun going faster again so as to gain 8 seconds from 1862 to 1872. So great an irregularity as this would require somewhat greater changes of sea-level, but not many times greater, than the British Association Commit-

tee's reductions of tidal observations for several places in different parts of the world, allow us to admit to have possibly taken place. The assumption of a fluid interior, which Newcomb suggests, and the flow of a large mass of the fluid "from equatorial regions to a position nearer the axis," is not, from what I have said to you, admissible as a probable explanation of the remarkable acceleration of rotational velocity which seems to have taken place about 1862; but happily it is not necessary. A settlement of 14 centimeters in the equatorial regions with corresponding rise of 28 centimeters at the poles, which is so slight as to be absolutely undiscoverable in astronomical observatories, and which would involve no change of sea-level absolutely disproved by reductions of tidal observations hitherto made would suffice. Such settlements must occur from time to time; and a settlement of the amount suggested might result from the diminution of centrifugal force due to 150 or 200 centuries' tidal retardation of the earth's rotational speed.

ART. LXII.—*Address at the Glasgow Meeting of the British Association, by* ALFRED RUSSEL WALLACE, President of the Section of Biology.

Introduction.

THE range of subjects comprehended within this Section is so wide, and my own acquaintance with them so imperfect and fragmentary, that it is not in my power to lay before you any general outline of the recent progress of the biological sciences. Neither do I feel competent to give you a summary of the present status of any one of the great divisions of our science—such as Anatomy, Physiology, Embryology, Histology, Classification, or Evolution—Philology, Ethnology, or Prehistoric Archæology; but there are fortunately several outlying and more or less neglected subjects to which I have for some time had my attention directed, and which I hope will furnish matter for a few observations, of some interest to biologists, and at the same time not unintelligible to the less scientific members of the Association who may honor us with their presence.

The subjects I first propose to consider have no general name, and are not easily grouped under a single descriptive heading; but they may be compared with that recent development of a sister-science, which has been termed Surface-geology, or Earth-sculpture. In the older geological works we learnt much about strata, and rocks, and fossils, their superposition, contortions, chemical constitution, and affinities, with some general notions of how they are formed in the remote past; but we often came

to the end of the volume no whit the wiser as to how and why the surface of the earth came to be so wonderfully and beautifully diversified; we were not told why some mountains are rounded and others precipitous; why some valleys are wide and open, others narrow and rocky; why rivers so often pierce through mountain-chains; why mountain lakes are often so enormously deep; whence came the gravel, and drift, and erratic blocks, so strangely spread over wide areas while totally absent from the other areas equally extensive. So long as these questions were almost ignored, geology could hardly claim to be a complete science, because, while professing to explain how the crust of the earth came to be what it is, it gave no intelligible account of the varied phenomena presented by its surface. But of late years these surface-phenomena have been assiduously studied; the marvellous effects of denudation and glacial action in giving the final touches to the actual contour of the earth's surface, and their relation to climatic changes and the antiquity of man, have been clearly traced, thus investing geology with a new and popular interest, and at the same time elucidating many of the phenomena presented in the older formations.

Now, just as a surface-geology was required to complete that science, so a surface-biology was wanted to make the science of living things more complete and more generally interesting, by applying the results arrived at by special workers, to the interpretation of those external and prominent features whose endless variety and beauty constitute the charm which attracts us to the contemplation or to the study of nature. We have the descriptive zoologist, for example, who gives us the external characters of animals; the anatomist studies their internal structure; the histologist makes known the nature of their component tissues; the embryologist patiently watches the progress of their development; the systematist groups them into classes and orders, families, genera, and species; while the field-naturalist studies for us their food and habits and general economy. But till quite recently, none of these earnest students, nor all of them combined, could answer satisfactorily, or ever attempted to answer, many of the simplest questions concerning the external characters and general relations of animals and plants. Why are flowers so wonderfully varied in form and color? What causes the Arctic fox and the ptarmigan to turn white in winter? Why are there no elephants in America and no deer in Australia? Why are closely allied species rarely found together? Why are male animals so frequently bright colored? Why are extinct animals so often larger than those which are now living? What has led to the production of the gorgeous train of the peacock and of the two kinds of flower in the primrose? The solution

of these and a hundred other problems of like nature, was rarely approached by the old method of study, or if approached was only the subject of vague speculation. It is to the illustrious author of the "Origin of Species" that we are indebted, for teaching us how to study nature as one great, compact, and beautifully adjusted system. Under the touch of his magic wand the countless isolated facts of internal and external structure of living things—their habits, their colors, their development, their distribution, their geological history,—all fell into their approximate places; and although, from the intricacy of the subject and our very imperfect knowledge of the facts themselves, much still remains uncertain; yet we can no longer doubt that even the minutest and most superficial peculiarities of animals and plants either, on the one hand, are or have been useful to them, or, on the other hand, have been developed under the influence of general laws, which we may one day understand to a much greater extent than we do at present. So great is the alteration effected in our comprehension of nature by the study of variation, inheritance, cross-breeding, competition, distribution, protection, and selection—showing, as they often do, the meaning of the most obscure phenomena, and the mutual dependence of the most widely-separated organisms, that it can only be fitly compared with the analogous alteration produced in our conception of the universe by Newton's grand discovery of the law of gravitation.

I know it will be said (and is said), that Darwin is too highly rated; that some of his theories are wholly and others partially erroneous, and that he often builds a vast superstructure on a very uncertain basis of doubtfully interpreted facts. Now, even admitting this criticism to be well founded- -and I myself believe that to a limited extent it is so—I nevertheless maintain that Darwin is not and cannot be too highly rated. For his greatness does not all depend upon his being infallible, but on his having developed, with rare patience and judgment, a new system of observation and study, guided by certain general principles which are almost as simple as gravitation, and as wide-reaching in their effects. And if other principles should hereafter be discovered, or if it be proved that some of his subsidiary theories are wholly or partially erroneous, this very discovery can only be made by following in Darwin's steps, by adopting the method of research which he has taught us, and by largely using the rich stores of material which he has collected. The "Origin of Species," and the grand series of works which have succeeded it, have revolutionized the study of biology. They have given us new ideas and fertile principles. They have infused life and vigor into our science, and have opened up hitherto unthought of lines of research on which

hundreds of eager students are now laboring. Whatever modifications some of his theories may require, Darwin must none the less be looked up to as the founder of philosophical biology.

As a small contribution to this great subject, I propose now to call your attention to some curious relations of organisms to their environment, which seem to me worthy of more systematic study than has hitherto been given them. The points I shall more especially deal with are—the influence of locality, or of some unknown local causes, in determining the colors of insects and, to a less extent, of birds: and the way in which certain peculiarities in the distribution of plants may have been brought about by their dependence on insects. The latter part of my address will deal with the present state of our knowledge as to the antiquity and early history of mankind.

2. *On some Relations of Living Things to their Environment.*

Of all the external characters of animals, the most beautiful, the most varied, and the most generally attractive, are the brilliant colors and strange yet often elegant markings with which so many of them are adorned. Yet, of all characters, this is the most difficult to bring under the laws of utility or of physical connection. Mr. Darwin—as you are well aware—has shown how wide is the influence of sex on the intensity of coloration; and he has been led to the conclusion that active or voluntary sexual selection is one of the chief causes, if not the chief cause, of all the variety and beauty of color we see among the higher animals. This is one of the points on which there is much divergence of opinion even among the supporters of Mr. Darwin, and one as to which I myself differ from him. I have argued, and still believe, that the need of protection is a far more efficient cause of variation of color than is generally suspected: but there are evidently other causes at work, and one of these seems to be an influence depending strictly on locality, whose nature we cannot yet understand, but whose effects are everywhere to be seen when carefully searched for.

Although the careful experiments of Sir John Lubbock have shown that insects can distinguish colors—as might have been inferred from the brilliant colors of the flowers which are such an attraction to them—yet we can hardly believe that their appreciation and love of distinctive colors is so refined as to guide and regulate their most powerful instinct—that of reproduction. We are therefore led to seek some other cause for the varied colors that prevail among insects; and as this variety is most conspicuous among butterflies,—a group perhaps better known than any other—it offers the best means of studying the subject. The variety of color and marking among these insects is something marvellous. There are probably about ten thousand

different kinds of butterflies now known, and about half of these are so distinct in color and marking that they can be readily distinguished by this means alone. Almost every conceivable tint and pattern is represented, and the hues are often of such intense brilliance and purity as can be equalled by neither birds nor flowers.

Any help to a comprehension of the causes which may have concurred in bringing about so much diversity and beauty must be of value, and this is my excuse for laying before you the more important cases I have met with of a connection between color and locality.

Our first example is from tropical Africa, where we find two unrelated groups of butterflies belonging to two very distinct families (Nymphalidæ and Papilionidæ) characterized by a prevailing blue green color not found in any other continent.* Again, we have a group of African Pieridæ which are white or pale yellow with a marginal row of bead-like black spots. and in the same country one of the Lycænidæ (*Liptena erastus*) is colored so exactly like these that it was at first described as a species of *Pieris.* None of these four groups are known to be in any way specially protected so that the resemblance cannot be due to protective mimicry.

In South America we have far more striking cases. For in the three sub-families— Danainæ, Acræniæ, and Heliconiinæ— all of which are specially protected, we find identical tints and patterns reproduced, often in the greatest detail, each peculiar type of coloration being characteristic of distinct geographical subdivisions of the continent. Nine very distinct genera are implicated in these parallel changes—*Lycorea*, *Ceratinia*, *Mechanitis*, *Ithomia*, *Melinœa*, *Tithorea*, *Acrœa*, *Heliconius*, and *Eueides* —groups of three or four (or even of five) of them appearing together in the same livery in one district, while in an adjoining district most or all of them undergo a simultaneous change of coloration or of marking. Thus in the genera *Ithomia*, *Mechanitis*, and *Heliconius*, we have species with yellow apical spots in Guiana, all represented by allied species with white apical spots in South Brazil. In *Mechanitis*, *Melinœa*, and *Heliconius*, and sometimes in *Tithorea*, the species of the Southern Andes (Bolivia and Peru) are characterized by an orange and black livery, while those of the Northern Andes (New Grenada) are almost always orange-yellow and black. Other changes of a like nature, which it would be tedious to enumerate, but which are very striking when specimens are examined, occur in species of the same groups inhabiting these same localities, as well as Central America and the Antilles. The resemblance thus pro-

* *Romaleosoma Euryphene* (Nymphalidæ), *Papilio salmoxis*, and several species of the *Nireus* group (Papilionidæ).

duced between widely different insects is sometimes general, but often so close and minute that only a critical examination of structure can detect the difference between them. Yet this can hardly be true mimicry, because all are alike protected by the nauseous secretion which renders them unpalatable to birds.

In another series of genera (*Catagramma*, *Callithea*, and *Agrias*), all belonging to the Nymphalidæ, we have the most vivid blue ground, with broad bands of orange-crimson or a different tint of blue or purple, exactly reproduced in corresponding, yet unrelated species, occurring in the same locality; yet, as none of these groups are protected, this can hardly be true mimicry. A few species of two other genera in the same country (*Eunice* and *Siderone*) also reproduce the same colors, but with only a general resemblance in the marking. Yet again, in Tropical America we have species of *Apatura* which, sometimes in both sexes, sometimes in the female only, exactly imitate the peculiar markings of another genus (*Heterochroa*) confined to America. Here, again, neither genus is protected, and the similarity must be due to unknown local causes.

But it is among islands that we find some of the most striking examples of the influence of locality on color, generally in the direction of paler, but sometimes of darker and more brilliant hues, and often accompanied by an unusual increase of size. Thus, in the Moluccas and New Guinea we have several Papilios (*P. euchenor*, *P. ormenus*, and *P. tydeus*), distinguished from their allies by a much paler color, especially in the females, which are almost white. Many species of *Danais* (forming the sub-genus *Iedopsis*) also very pale. But the most curious are the Euplœas, which, in the larger islands, are usually of rich dark colors, while in the small islands of Banda, Ké, and Matabello at least three species not nearly related to each other (*E. Hoppferi*, *E. euripon*, and *E. assimilata*) are all broadley banded or suffused with white, their allies in the larger islands being all very much darker. Again, in the genus *Diadema*, belonging to a distinct family, three species from the small Aru and Ké islands (*D. deois*, *D. Hewitsonii*, and *D. polymena*) are all more conspicuously white-marked than their representatives in the larger islands. In the beautiful genus *Cethosia*, a species from the small island of Waigiou (*C. cyrene*), is the whitest of the genus. *Prothoe* is represented by a blue species in the continental island of Java, while those inhabiting the ancient insular groups of the Moluccas and New Guinea are all pale yellow or white. The genus *Drusilla*, almost confined to these islands, comprises many species which are all very pale; while in the small island of Waigiou is found a very distinct genus, *Hyantis*, which, though differing completely in the neuration of the wings, has exactly the same pale

colors and large ocellated spots as *Drusilla*. Equally remarkable is the fact that the small island of Amboina produces larger-sized butterflies than any of the larger islands which surround it. This is the case with at least a dozen butterflies belonging to many distinct genera,* so that it is impossible to attribute it to other than some local influence. In Celebes, as I have elsewhere pointed out,† we have a peculiar form of wing and much larger size running through a whole series of distinct butterflies, and this seems to take the place of any specialty in color.

From the Fiji Islands we have comparatively few butterflies, but there are several species of *Diadema* of unusually pale colors, some almost white.

The Philipine Islands seem to have the peculiarity of developing metallic colors. We find there at least three species of *Euplœa*‡ not closely related, and all of more intense metallic luster than their allies in other islands. Here also we have one of the large yellow Ornithopteræ (*O. Magellanus*), whose hind wings glow with an intense opaline luster not found in any other species of the entire group; and an *Adolias*§ is larger and of more brilliant metallic coloring than any other species in the Archipelago. In these islands also we find the extensive and wonderful genus of weevils, *Pachyrhynchus*, which in their brilliant metallic coloring surpass anything found in the whole eastern hemisphere, if not in the whole world.

In the Andaman Islands, in the Bay of Bengal, there are a considerable number of peculiar species of butterflies differing slightly from those on the continent, and generally in the direction of paler or more conspicuous coloring. Thus, two species of *Papilio*, which on the continent have the tails black, in their Andaman representatives have them either red or white-tipped.‖ Another species** is richly blue-banded where its allies are black; while three species of distinct genera of Nymphalidæ†† all differ from their allies on the continent in being of excessively pale colors, as well as of somewhat larger size.

In Madagascar we have the very large and singularly white-spotted *Papilio antenor*, while species of three other genera‡‡ are very white or conspicuous, compared with their continental allies.

* *Ornithoptera priamus*, *O. helena*, *Papilio deiphobus*, *P. Ulysses*, *P. Gambrisius*, *P. codrus*, *Iphias leucippe*, *Euplœa prothöe*, *Hestia idea*, *Athyma jocaste*, *Diadema pandarus*, *Nymphalis pyrrhus*, *N. euryalus*, *Drusilla jairus*.

† "Contributions to the Theory of Natural Selection," pp. 168–173.

‡ *Euplœa Hewitsonii*, *E. Diocletiana*, *E. lætifica*, *E. dupesnii*.

§ *Adolias calliphorus*.

‖ *Papilio rhodifer* (near *P. Doubledayi*) and *Papilio charicles* (near *P. memnon*).

** *Papilio mayo*.

†† *Euplœa Andamanensis*, *Cethosia biblis*, *Cyrestis cocles*.

‡‡ *Danais nossima*, *Melanitis massoura*, *Diadema dexithea*.

Passing to the West Indian Islands and Central America (which latter country has formed a group of islands in very recent times), we have similar indications. One of the largest of the Papilios inhabits Jamaica,* while another, the largest of its group, is found in Mexico.† Cuba has two of the same fine genus, whose colors are of surpassing brilliancy;‡ while the genus *Clothilda*—confined to the Antilles and Central America—is remarkable for its rich and showy coloring.

Persons who are not acquainted with the important structural differences that distinguish these various genera of butterflies, can hardly realize the importance and the significance of such facts as I have now detailed. It may be well, therefore, to illustrate them by supposing parallel cases to occur among the mammalia. We might have, for example, in Africa, the gnus, the elands, and the buffaloes all colored and marked like zebras, stripe for stripe over the whole body exactly corresponding. So the hares, marmots, and squirrels of Europe might be all red, with black feet, while the corresponding species of Central Asia were all yellow, with black heads. In North America we might have raccoons, squirrels, and opossums in parti-colored livery of white and black, so as exactly to resemble the skunk of the same country; while in South America they might be black, with a yellow throat patch, so as to resemble with equal closeness the tayra of the Brazilian forests. Were such resemblances to occur in anything like the number, and with the wonderful accuracy of imitation met with among the Lepidoptera, they would certainly attract universal attention among naturalists, and would lead to the exhaustive study of the influence of local causes in producing such startling results.

One somewhat similar case does indeed occur among the mammalia, two singular African animals, the Aard-wolf (*Proteles*) and the Hyæna-dog (*Lycaon*), both strikingly resembling hyænas in their general form as well as in their spotted markings. Belonging as they all do to the Carnivora, though to three distinct families, it seems quite an analogous case to those we have imagined; but as the Aard-wolf and the hyæna-dog are both weak animals compared with the hyæna, the resemblance may be useful, and in that case would come under the head of mimicry. This seems the more probable because, as a rule, the colors of the Mammalia are protective, and are too little varied to allow of the influence of local causes producing any well-marked effects.

When we come to the birds, however, the case is different; for although they do not exhibit such distinct marks of the influence of locality as do butterflies—probably because the causes

* *Papilio Homerus.* † *P. daunus.* ‡ *P. Gundlachianus, P. Villiersi.*

which determine color are in their case more complex—yet there are distinct indications of some effect of the kind, and we must devote some little time to their consideration.

One of the most curious cases is that of the parrots of the West Indian Islands and Central America, several of which have white heads or foreheads, occurring in two distinct genera,* while none of the more numerous parrots of South America are so colored. In the small island of Dominica we have a very large and richly-colored parrot (*Chrysotis augusta*) corresponding to the large and richly-colored *Papilio homerus* of Jamaica.

The Andaman Islands are equally remarkable, at least six of the peculiar birds differing from their continental allies in being much lighter, and sometimes with a large quantity of pure white in the plumage,† exactly corresponding to what occurs among the butterflies.

In the Philipines this is not so marked a feature,—yet we have here the only known white-breasted Kingcrow (*Dicrurus mirabilis*),—the newly discovered *Eurylæmus Steerii*, wholly white beneath,—three species of *Diceum*, all white beneath,—several species of *Parus*, largely white-spotted,—while many of the pigeons have light ashy tints. The birds generally, however, have rich-dark colors, similar to those which prevail among the butterflies.

In Celebes we have a swallow-shrike and a peculiar small crow allied to the jackdaw,‡ whiter than any of their allies in the surrounding islands, but otherwise the colors of the birds call for no special remark.

In Timor and Flores we have white-headed pigeons,§ and a long-tailed flycatcher almost entirely white.‖

In the small Lord Howe's Island we have the recently extinct white rail (*Notornis alba*), remarkably contrasting with its allies in the larger islands in New Zealand.

We cannot, however lay any stress on isolated examples of white colors, since these occur in most of the great continents, but where we find a series of species of distinct genera, all differing from their continental allies in a whiter coloration, as in the Andaman Islands and the West Indies; and among butterflies, in the smaller Moluccas, the Andamans, and Madagascar, we cannot avoid the conclusion that in these insular localities some general cause is at work.

There are other cases, however, in which local influences seem to favor the production of preservation of intense crimson

* *Pionus albifrons* and *Chrysotis senilis* (C. America), *Chrysotis Sallæi* (Hayti).

† *Kittacincla albiventris*, *Geocichla albigularis*, *Sturnia Andamanensis*, *Hyloterpe grisola*, *var.*, *Fanthænas palumboides*, *Osmotreron chloroptera*.

‡ *Artamus monachus*, *Corvus advena*.

§ *Ptilopus cinctus*, *P. albocinctus*.

‖ *Tchiterea affinis*, *var.*

or a very dark coloration. Thus in the Moluccas and New Guinea alone we have bright red parrots belonging to two distinct families,* and which, therefore, most probably have been independently produced or preserved by some common cause. Here too and in Australia we have black parrots and pigeons;† and it is a most curious and suggestive fact that in another insular sub-region—that of Madagascar and the Mascarene Islands—these same colors reappear in the same two groups.‡

Some very curious physiological facts bearing upon the presence or absence of white colors in the higher animals have lately been adduced by Dr. Ogle.§ It has been found that a colored or dark pigment in the olfactory region of the nostrils is essential to perfect smell, and this pigment is rarely deficient except when the whole animal is purely white. In these cases the creature is almost without smell or taste. This, Dr. Ogle believes, explains the curious case of the pigs in Virginia adduced by Mr. Darwin, white pigs being poisoned by a poisonous root which does not affect black pigs. Mr. Darwin imputed this to a constitutional difference accompanying the dark color, which rendered what was poisonous to the white-colored animals quite innocuous to the black. Dr. Ogle, however, observes, that there is no proof that the black pigs eat the root, and he believes the more probable explanation to be that it is distasteful to them, while the white pigs, being deficient in smell and taste, eat it and are killed. Analogous facts occur in several distinct families. White sheep are killed in the Tarentino by eating *Hypericum criscum*, while black sheep escape; white rhinoceroses are said to perish from eating *Euphorbia candelabrum;* and white horses are said to suffer from poisonous food where colored ones escape. Now it is very improbable that a constitutional immunity from poisoning by so many distinct plants should in the case of such widely different animals be always correlated with the same difference of color; but the facts are readily understood if the senses of smell and taste are dependent on the presence of a pigment which is deficient in wholly white animals. The explanation has however, been carried a step further, by experiments showing that the absorption of odor by dead matter, such as clothing, is greatly affected by color, black being the most powerful absorbent, then blue, red, yellow, and lastly white. We have here a physical cause for the sense-inferiority of totally white animals which may account for their rarity in nature. For few, if any, wild animals are wholly white. The head, the face, or

* *Lorius, Eos* (Trichoglossidæ), *Eclectus* (Palæornithidæ).
† *Microglossus, Calyptorhynchus, Turacæna.*
‡ *Coracopsis, Alectrœnas.*
§ Medico-Chirurgical Transactions, vol. liii, (1870).

at least the muzzle or the nose, are generally black. The ears and eyes are also often black; and there is reason to believe that dark pigment is essential to good hearing, as it certainly is to perfect vision. We can therefore understand why white cats with blue eyes are so often deaf—a peculiarity we notice more readily than their deficiency of smell or taste.

If then the prevalence of white coloration is generally accompanied with some deficiency in the acuteness of the most important senses, the color becomes doubly dangerous, for it not only renders its possessors more conspicuous to its enemies, but at the same time makes it less ready in detecting the presence of danger. Hence, perhaps, the reason why white appears more frequently in islands where competition is less severe and enemies less numerous and varied. Hence, also, a reason why *albinoism*, although freely occurring in captivity never maintains itself in a wild state, while *melanism* does. The peculiarity of some islands in having all their inhabitants of dusky colors—as the Galapagos—may also perhaps be explained on the same principles, for poisonous fruits or seeds may there abound which weed out all white or light-colored varieties, owing to their deficiency of smell and taste. We can hardly believe, however, that this would apply to white-colored butterflies, and this may be a reason why the effect of an insular habitat is more marked in these insects than in birds or mammals. But though inapplicable to the lower animals, this curious relation of sense-acuteness with colors may have had some influence on the development of the higher human races. If light tints of the skin were generally accompanied by some deficiency in the sense of smell, hearing, and vision, the white could never compete with the darker races, so long as man was in a very low or savage condition, and wholly dependent for existence on the acuteness of his senses. But as the mental faculties became more fully developed and more important to his welfare than mere sense-acuteness, the lighter tints of skin, and hair, and eyes, would cease to be disadvantageous whenever they were accompanied by superior brain-power. Such variations would then be preserved; and thus may have arisen the Xanthochroic race of mankind, in which we find a high development of intellect accompanied by a slight deficiency in the acuteness of the senses as compared with the darker forms.

I have now to ask your attention to a few remarks on the peculiar relations of plants and insects as exhibited in islands.

Ever since Mr. Darwin showed the immense importance of insects in the fertilization of flowers, great attention has been paid to the subject, and the relation of these two very different classes of natural objects has been found to be more universal

and more complex than could have been anticipated. Whole genera and families of plants have been so modified, as first to attract, and then to be fertilized by, certain groups of insects, and this special adaptation seems in many cases to have determined the more or less wide range of the plants in question. It is also known that some species of plants can be fertilized only by particular species of insects, and the absence of these from any locality would necessarily prevent the continued existence of the plant in that area. Here, I believe, will be found the clue to much of the peculiarity of the floras of oceanic islands, since the methods by which they have been stocked with plants and insects will be often quite different. Many seeds are, no doubt, carried by oceanic currents, others probably by aquatic birds. Mr. H. N. Moseley informs me that the albatrosses, gulls, puffins, tropic birds, and many others, nest inland, often amidst dense vegetation, and he believes they often carry seeds, attached to their feathers, from island to island for great distances. In the tropics they often nest on the mountains far inland, and may thus aid in the distribution even of mountain plants. Insects, on the other hand, are mostly conveyed by aërial currents, especially by violent gales; and it may thus often happen that totally unrelated plants and insects may be brought together, in which case the former must often perish for want of suitable insects to fertilize them. This will, I think, account for the strangely fragmentary nature of these insular floras, and the great distances that often exist between those which are situated in the same ocean, as well as for the preponderance of certain orders and genera. In Mr. Pickering's valuable work on the Geographical Distribution of Animals and Plants, he gives a list of no less than sixty-six natural orders of plants *unexpectedly* absent from Tahiti, or which occur in many of the surrounding lands, some being abundant in other islands—as the Labiatæ at the Sandwich Islands. In these latter islands the flora is much richer, yet a large number of families which abound in other parts of Polynesia are totally wanting. Now much of the poverty and exceptional distribution of the plants of these islands is probably due to the great scarcity of flower-frequenting insects. Lepidoptera and Hymenoptera are exceedingly scarce in the eastern islands of the Pacific, and it is almost certain that many plants which require these insects for their fertilization have been thereby prevented from establishing themselves. In the Western islands, such as the Fijis, several species of butterflies occur in tolerable abundance, and no doubt some flower-haunting Hymenoptera accompany them, and in these islands the flora appears to be much more varied, and especially to be characterized by a much greater variety of showy flowers,

as may be seen by examining the plates of Dr. Seeman's "Flora Vitiensis."

Darwin and Pickering both speak of the great preponderance of ferns at Tahiti, and Mr. Moseley, who spent several days in the interior of the island, informs me that "at an elevation of from 2,000 to 3,000 feet the dense vegetation is composed almost entirely of ferns. A tree fern (*Alsophila Tahitensis*) forms a sort of forest, to the exclusion of almost every other tree, and, with huge plants of two other ferns (*Angiopteris erecta* and *Aspelenium nidus*), forms the main mass of the vegetation." And he adds, "I have nowhere seen ferns in so great proportionate abundance." This unusual proportion of ferns is a general feature of insular as compared with continental floras; but it has, I believe, been generally attributed to favorable conditions, especially to equable climate and perennial moisture. In this respect, however, Tahiti can hardly differ greatly from many other islands, which yet have no such vast preponderance of ferns. This is a question that cannot be decided by mere lists of species, since it is probable that in Tahiti they are less numerous than in some other islands where they form a far less conspicuous feature in the vegetation. The island most comparable with Tahiti in that respect is Juan Fernandez. Mr. Moseley writes to me—"In a general view of any wide stretch of densely-clothed mountainous surface of the island, the ferns, both tree-ferns and the unstemmed forms, are seen at once to compose a very large proportion of the mass of foliage." As to the insects of Juan Fernandez, Mr. Edwyn C. Reed, who made two visits and spent several weeks there, has kindly furnished me with some exact information. Of butterflies there is only one (*Pyrameis carie*), and that rare—a Chilian species and probably an accidental straggler. Four species of moths of moderate size were observed—all Chilian, and a few larvæ and pupæ. Of bees there were none, except one very minute species (allied to *Chilicola*), and of other Hymenoptera, a single specimen of *Ophion luteus*—a cosmopolitan ichneumon. About twenty species of flies were observed, and these formed the most prominent feature of the entomology of the island.

Now, as far as we know, the extreme entomological poverty agrees closely with that of Tahiti; and there are probably no other portions of the globe equally favored in soil and climate and with an equally luxuriant vegetation, where insect-life is so scantily developed. It is curious therefore to find that these two islands also agree in the wonderful predominance of ferns over the flowering plants—in individuals even more than in species, and there is no difficulty in connecting the two facts. The excessive minuteness and great abundance of fern-spores causes them to be far more easily distributed by winds than the

seeds of flowering plants, and they are thus always ready to occupy any vacant places in suitable localities, and to compete with the less vigorous flowering plants. But where insects are so scarce, all plants which require insect fertilization, whether constantly to enable them to produce seed at all, or occasionally to keep up their constitutional vigor by crossing, must be at a great disadvantage; and thus the scanty flora which oceanic islands must always possess, peopled as they usually are by waifs and strays from other lands, is rendered still more scanty by the weeding out of all such as depend largely on insect fertilization for their full development. It seems probable, therefore, that the preponderance of ferns in islands (considered in mass of individuals rather than in number of species) is largely due to the absence of competing phenogamous plants; and that this is in great part due to the scarcity of insects. In other oceanic islands, such as New Zealand and the Galapagos, where ferns, although tolerably abundant, form no such predominant feature in the vegetation, but where the scarcity of flower-haunting insects is almost equally marked, we find a great preponderance of small green, or otherwise inconspicuous flowers, indicating that only such plants have been enabled to flourish there as are independent of insect fertilization. In the Galapagos—which are perhaps even more deficient in flying insects than Juan Fernandez—this is so striking a feature that Mr. Darwin speaks of the vegetation as consisting in great part of "wretched-looking weeds," and states that "it was some time before he discovered that almost every plant was in flower at the time of his visit." He also says that he "did not see one beautiful flower" in the islands. It appears, however, that Compositæ, Leguminosæ, Rubiaceæ, and Solanaceæ, form a large proportion of the flowering plants, and as these are orders which usually require insect fertilization, we must suppose either that they have become modified so as to be self-fertilized, or that they are fertilized by the visits of the minute Diptera and Hymenoptera, which are the only insects recorded from these islands.

In Juan Fernandez, on the other hand, there is no such total deficiency of showy flowers. I am informed by Mr. Moseley that a variety of the Magnoliaceous winter's bark abounds, and has showy white flowers, and that a Bignoniaceous shrub with abundance of dark blue flowers, was also plentiful; while a white-flowered Liliaceous plant formed large patches on the hill-sides. Besides these there were two species of woody Compositæ with conspicuous heads of yellow blossoms, and a species of white-flowered myrtle also abundant; so that, on the whole, flowers formed a rather conspicuous feature in the aspect of the vegetation of Juan Fernandez.

But this fact—which at first sight seems entirely at variance

with the view we are upholding of the important relation between the distribution of insects and plants—is well explained by the existence of two species of humming birds in Juan Fernandez, which, in their visits to these large and showy flowers fertilize them as effectually as bees, moths, or butterflies. Mr. Moseley informs me that "these humming birds are *extraordinarily abundant*, every tree or bush having one or two darting about it." He also observed that "nearly all the specimens killed had the feathers round the base of the bill and front of the head clogged and colored yellow with pollen." Here, then, we have the clue to the perpetuation of large and showy flowers in Juan Fernandez; while the total absence of humming-birds in the Galapagos may explain why no such large-flowered plants have been able to establish themselves in those equatorial islands.

This leads to the observation that many other groups of birds also, no doubt, aid in the fertilization of flowers. I have often observed the beaks and faces of the brush-tongued lories of the Moluccas covered with pollen; and Mr. Moseley noted the same fact in a species of *Artamus*, or swallow-shrike, shot at Cape York, showing that this genus also frequents flowers and aids in their fertilization. In the Australian region we have the immense group of the Meliphagidæ, which all frequent flowers, and as these range over all the islands of the Pacific, their presence will account for a certain proportion of showy flowers being found there, such as the scarlet *Metrosideros*, one of the few conspicuous flowers in Tahiti. In the Sandwich Islands, too, there are forests of *Metrosideros*; and Mr. Charles Pickering writes me, that they are visited by honey-sucking birds, one of which is captured by sweetened bird-lime, against which it thrusts its extensile tongue. I am also informed that a considerable number of flowers are occasionally fertilized by humming-birds in North America; so that there can, I think, be little doubt that birds play a much more important part in this respect than has hitherto been imagined. It is not improbable that in Tropical America, where this family is so enormously developed, many flowers will be found to be expressly adapted to fertilization by them just as so many in our own country are specially adapted to the visits of certain families or genera of insects.

It must also be remembered, as Mr. Moseley has suggested to me, that a flower which had acquired a brilliant color to attract insects might, on transference to another country, and becoming so modified as to be capable of self-fertilization, retain the colored petals for an indefinite period. Such is probably the explanation of the *Pelargonium* of Kerguelen's land, which forms masses of bright color near the shore during the flower-

ing season; while most of the other plants of the island have colorless flowers in accordance with the almost total absence of winged insects. The presence of many large and showy flowers among the indigenous flora of St. Helena must be an example of a similar persistence. Mr. Melliss indeed states it to be "a remarkable peculiarity that the indigenous flowers are, with very slight exceptions, all perfectly colorless;"* but although this may apply to the general aspect of the remains of the indigenous flora, it is evidently not the case as regards the *species*, since the interesting plates of Mr. Melliss's volume show that about one-third of the indigenous flowering plants have more or less colored or conspicuous flowers, while several of them are exceedingly showy and beautiful. Among these are a *Lobelia*, three *Wahlenbergias*, several *Compositæ*, and especially the handsome red flowers of the now almost extinct forest-trees, the ebony and redwood (species of *Melhania*, Byttneriaceæ). We have every reason to believe, however, that when St. Helena was covered with luxuriant forests, and especially at that remote period when it was much more extensive than it is now, it must have supported a certain number of indigenous birds and insects, which would have aided in the fertilization of these gaily-colored flowers. The researches of Dr. Hermann Müller have shown us by what minute modification of structure or of function many flowers are adapted for partial insect and self-fertilization in varying degrees, so that we have no difficulty in understanding how, as the insects diminished and finally disappeared, self-fertilization may have become the rule, while the large and showy corollas remain to tell us plainly of a once different state of things.

Another interesting fact in connection with this subject is the presence of arborescent forms of Compositæ in so many of the remotest oceanic islands. They occur in the Galapagos, in Juan Fernandez, in St. Helena, in the Sandwich Islands, and in New Zealand; but they are not directly related to each other, representatives of totally different tribes of this extensive order becoming arborescent in each group of islands. The immense range and almost universal distribution of the Compositæ is due to the combination of a great facility of distribution (by their seeds), with a great attractiveness to insects, and the capacity of being fertilized by a variety of species of all orders, and especially by flies and small beetles. Thus they would be among the earliest of flowering plants to establish themselves on oceanic islands; but where insects of all kinds were very scarce it would be an advantage to gain increased size and longevity, so that fertilization at an interval of several years might suffice for the continuance of the species. The arborescent form would com-

* Melliss's *St. Helena*, p. 226, note.

bine with increased longevity the advantage of increased size in the struggle for existence with the ferns and other early colonists, and these advantages have led to its being independently produced in so many distant localities, whose chief feature in common is their remoteness from continents and the extreme poverty of their insect life.

As the sweet odors of flowers are known to act in combination with their colors, as an attraction to insects, it might be anticipated that where color was deficient scent would be so also. On applying to my friend Dr. Hooker for information as to New Zealand plants, he informed me that this was certainly the case, and that the New Zealand flora is, speaking generally, as strikingly deficient in sweet odors as in conspicuous colors. Whether this peculiarity occurs in other islands I have not been able to obtain information, but we may certainly expect it to be so in such a marked instance as that of the Galapagos flora.

Another question which here comes before us is the origin and meaning of the odoriferous glands of leaves. Dr. Hooker informed me that not only are New Zealand plants deficient in scented flowers, but equally so in scented leaves. This led me to think that perhaps such leaves were in some way an additional attraction to insects, though it is not easy to understand how this could be, except by adding a general attraction to the special attraction of the flowers, or by supporting the larvæ, which as perfect insects aid in fertilization. Mr. Darwin, however, informs me that he considers that leaf-glands bearing essential oils are a protection against the attacks of insects where these abound, and would thus not be required in countries where insects were very scarce. But it seems opposed to this view that highly aromatic plants are characteristic of deserts all over the world, and in such places insects are not abundant. Mr. Stainton informs me that the aromatic Labiatæ enjoy no immunity from insect attacks. The bitter leaves of the cherry-laurel are often eaten by the larvæ of moths that abound on our fruit-trees; while in the Tropics the leaves of the orange tribe are favorites with a large number of lepidopterous larvæ; and our northern firs and pines, although abounding in a highly aromated resin, are very subject to the attacks of beetles. My friend Dr. Richard Spruce—who while traveling in South America allowed nothing connected with plant-life to escape his observation—informs me that trees whose leaves have aromatic and often resinous secretions in immersed glands abound in the plains of tropical America, and that such are in great part, if not wholly, free from the attacks of leaf-eating ants, except where the secretion is only slightly bitter, as in the orange tribe, orange-trees being sometimes entirely denuded

of their leaves in a single night. Aromatic plants abound in the Andes up to about 13,000 feet, as well as in the plains, but hardly more so than in Central and Southern Europe. They are perhaps most plentiful in the dry mountainous parts of Southern Europe; and as neither here nor in the Andes do leaf-eating ants exist, Dr. Spruce infers that, although in the hot American forests where such ants swarm the oil-bearing glands serve as a protection, yet they were not originally acquired for that purpose. Near the limits of perpetual snow on the Andes such plants as occur are not, so far as Dr. Spruce has observed, aromatic; and as plants in such situations can hardly depend on insect visits for their fertilization, the fact is comparable with that of the flora of New Zealand, and would seem to imply some relation between the two phenomena, though what it exactly is cannot yet be determined.

I trust I have now been able to show you that there are a number of curious problems lying as it were on the outskirts of biological inquiry which well merit attention, and which may lead to valuable results. But these problems are, as you see, for the most part connected with questions of locality, and require full and accurate knowledge of the productions of a number of small islands and other limited areas, and the means of comparing them the one with the other. To make such comparisons is, however, now quite impossible. No museum contains any fair representation of the productions of these localities, and such specimens as do exist, being scattered through the general collection, are almost useless for this special purpose. If, then, we are to make any progress in this inquiry, it is absolutely essential that some collectors should begin to arrange their cabinets primarily on a geographical basis, keeping together the productions of every island or group of islands, and of such divisions of each continent as are found to possess any special or characteristic fauna or flora. We shall then be sure to detect many unsuspected relations between the animals and plants of certain localities, and we shall become much better acquainted with those complex reactions between the vegetable and animal kingdoms, and between the organic world and the inorganic, which have almost certainly played an important part in determining many of the most conspicuous features of living things.

3. *Rise and Progress of Modern Views as to the Antiquity and Origin of Man.*

I now come to a branch of our subject which I would gladly have avoided touching on, but as the higher powers of this Association have decreed that I should preside over the Anthropological Department, it seems proper that I should devote

some portion of my address to matters more immediately connected with the special study to which that department is devoted.

As my own knowledge of, and interest in, Anthropology, is confined to the great outlines, rather than to the special details of the science, I propose to give a very brief and general sketch of the modern doctrine as to the Antiquity and Origin of Man, and to suggest certain points of difficulty which have not, I think, yet received sufficient attention.

Many now present remember the time (for it is a little more than twenty years ago) when the antiquity of man, as now understood, was universally discredited. Not only theologians, but even geologists, then taught us that man belonged altogether to the existing state of things; that the extinct animals of the Tertiary period had finally disappeared, and that the earth's surface had assumed its present condition before the human race first came into existence. So prepossessed were even scientific men with this idea—which yet rested on purely negative evidence, and could not be supported by any arguments of scientific value—that numerous facts which had been presented at intervals for half a century, all tending to prove the existence of man at very remote epochs, were silently ignored; and, more than this, the detailed statements of three distinct and careful observers were rejected by a great scientific society as too improbable for publication, only because they proved (if they were true) the co-existence of man with extinct animals!*

But this state of belief in opposition to facts could not long continue. In 1859 a few of our most eminent geologists examined for themselves into the alleged occurrence of flint implements in the gravels of the North of France, which had been made public fourteen years before, and found them strictly correct. The caverns of Devonshire were about the same time carefully examined by equally eminent observers, and were found fully to bear out the statement of those who had published their results eighteen years before. Flint implements began to be found in all suitable localities in the South of England, when carefully searched for, often in gravels of equal antiquity with those of France. Caverns, giving evidence of human occupation at various remote periods, were explored in Belgium and the South of France,—lake dwellings were examined in Switzerland—refuse heaps in Denmark—and thus a whole series of remains have been discovered carrying back the history of mankind from the earliest historic periods to a

*** In 1854 (?) a communication from the Torquay Natural History Society confirming previous accounts by Mr. Godwin-Austen, Mr. Vivian, and the Rev. Mr. McEnery, that worked flints occurred in Kent's Hole with remains of extinct species, was rejected as too improbable for publication.**

long distant past. The antiquity of the races thus discovered can only be generally determined by the successively earlier and earlier stages through which we can trace them. As we go back, metals soon disappear and we find only tools and weapons of stone and of bone. The stone weapons get ruder and ruder; pottery, and then the bone implements, cease to occur; and in the earliest stage we find only chipped flints, of rude design though still of unmistakable human workmanship. In like manner domestic animals disappear as we go backward; and though the dog seems to have been the earliest, it is doubtful whether the makers of the ruder flint implements of the gravels possessed even this. Still more important as a measure of time are the changes of the earth's surface—of the distribution of animals—and of climate—which have occurred during the human period. At a comparatively recent epoch in the record of prehistoric times we find that the Baltic was far salter than it is now, and produced abundance of oysters; and that Denmark was covered with pine forests inhabited by Capercailzies, such as now only occur further north in Norway. A little earlier we find that Reindeer were common even in the South of France, and still earlier this animal was accompanied by the mammoth and woolly rhinoceros, by the arctic glutton, and by huge bears and lions of extinct species. The presence of such animals implies a change of climate, and both in the caves and gravels we find proofs of a much colder climate than now prevails in Western Europe. Still more remarkable are the changes of the earth's surface which have been effected during man's occupation of it. Many extensive valleys in England and France are believed by the best observers to have been deepened at least a hundred feet; caverns now far out of the reach of any stream must for a long succession of years have had streams flowing through them, at least in times of floods—and this often implies that vast masses of solid rock have since been worn away. In Sardinia land has risen at least 300 feet since men lived there who made pottery and probably used fishing-nets;* while in Kent's Cavern remains of man are found buried beneath two separate beds of stalagmite, each having a distinct texture, and each covering a deposit of cave-earth having well-marked differential characters, while each contains a distinct assemblage of extinct animals.

Such, briefly, are the results of the evidence that has been rapidly accumulating for about fifteen years as to the antiquity of man; and it has been confirmed by so many discoveries of a like nature in all parts of the globe, and especially by the comparison of the tools and weapons of prehistoric man with those of modern savages, so that the use of even the rudest flint im-

* Lyell's Antiquity of Man, fourth edition, p. 115.

plements has become quite intelligible,—that we can hardly wonder at the vast revolution effected in public opinion. Not only is the belief in man's vast and still unknown antiquity universal among men of science, but it is hardly disputed by any well-informed theologian; and the present generation of science-students must, we should think, be somewhat puzzled to understand, what there was in the earlier discoveries that should have aroused such general opposition and been met with such universal incredulity.

But the question of the mere "Antiquity of Man" almost sank into insignificance at a very early period of the inquiry, in comparison with the far more momentuous and more exciting problem of the development of man from some lower animal form, which the theories of Mr. Darwin and of Mr. Herbert Spencer soon showed to be inseparably bound up with it. This has been, and to some extent still is, the subject of fierce conflict; but the controversy as to the fact of such development is now almost at an end, since one of the most talented representatives of Catholic theology, and an anatomist of high standing —Professor Mivart—fully adopts it as regards physical structure, reserving his opposition for those parts of his theory, which would deduce man's whole intellectual and moral nature from the same source, and by a similar mode of development.

Never, perhaps, in the whole history of science or philosophy has so great a revolution in thought and opinion been effected as in the twelve years from 1859 to 1871, the respective dates of publication of Mr. Darwin's "Origin of Species" and "Descent of Man." Up to the commencement of this period the belief in the independent creation or origin of the species of animals and plants, and the very recent appearance of man upon the earth, were, practically, universal. Long before the end of it these two beliefs had utterly disappeared, not only in the scientific world, but almost equally so among the literary and educated classes generally. The belief in the independent origin of man held its ground somewhat longer, but the publication of Mr. Darwin's great work gave even that its deathblow, for hardly anyone capable of judging of the evidence now doubts the derivative nature of man's bodily structure as a whole, although many believe that his mind and even some of his physical characteristics may be due to the action of other forces than have acted in the case of the lower animals.

We need hardly be surprised, under these circumstances, if there has been a tendency among men of science to pass from one extreme to the other, from a profession (so few years ago) of total ignorance as to the mode of origin of all living things, to a claim to almost complete knowledge, of the whole progress of the universe, from the first speck of living protoplasm up to

the highest development of the human intellect. Yet this is really what we have seen in the last sixteen years. Formerly difficulties were exaggerated, and it was asserted that we had not sufficient knowledge to venture on any generalizations on the subject. Now difficulties are set aside, and it is held that our theories are so well established and so far-reaching, that they explain and comprehend all nature. It is not long ago (as I have already reminded you) since *facts* were contemptuously ignored, because they favored our now popular views; at the present day it seems to me that facts which oppose them hardly receive due consideration. And as opposition to the best incentive to progress, and it is not well even for the best theories to have it all their own way, I propose to direct your attention to a few such facts, and to the conclusion that seems fairly deducible from them.

It is a curious circumstance, that notwithstanding the attention that has been directed to the subject in every part of the world, and the numerous excavations connected with railways and mines which have offered such facilities for geological discovery, no advance whatever has been made for a considerable number of years, in detecting the time or the mode of man's origin. The Palæolithic flint weapons first discovered in the North of France more than thirty years ago, are still the oldest undisputed proofs of man's existence; and amid the countless relics of a former world that have been brought to light, no evidence of any one of the links that must have connected man with the lower animals has yet appeared.

It is, indeed, well known that negative evidence in geology is of very slender value, and this is, no doubt, generally the case. The circumstances here are, however, peculiar, for many converging lines of evidence show that on the theory of development by the same laws which have determined the development of the lower animals, man must be immensely older than any traces of him yet discovered. As this is a point of great interest we must devote a few moments to its consideration.

1. The most important difference between man and such of the lower animals as most nearly approach him, is undoubtedly in the bulk and development of his brain, as indicated by the form and capacity of the cranium. We should therefore anticipate that these earliest races, who were contemporary with the extinct animals and used rude stone weapons, would show a marked deficiency in this respect. Yet the oldest known crania—those of the Engis and Cro-Magnon caves—show no marks of degradation. The former does not present so low a type as that of most existing savages, but is—to use the words of Prof. Huxley—"a fair average human skull, which might have belonged to a philosopher, or might have contained the

thoughtless brains of a savage." The latter are still more remarkable, being unusually large and well-formed. Dr. Pruner-Bey states that they surpass the average of modern European skulls in capacity, while their symmetrical forms, without any trace of prognathism, compares favorably not only with the foremost savage races, but with many civilized nations of modern times.

One or two other crania of much lower type, but of less antiquity than this, have been discovered; but they in no way invalidate the conclusion which so highly developed a form at so early a period implies, viz., that we have as yet made a hardly perceptible step toward the discovery of any earlier stage in the development of man.

2. This conclusion is supported and enforced by the nature of many of the works of art found even in the oldest cave-dwellings. The flints are of the old chipped type, but they are formed into a large variety of tools and weapons—such as scrapers, awls, hammers, saws, lances, &c., implying a variety of purposes for which these were used, and a corresponding degree of mental activity and civilization. Numerous articles of bone have also been found, including well-formed needles, implying that skins were sewn together, and perhaps even textile materials woven into cloth. Still more important are numerous carvings and drawings representing a variety of animals, including horses, reindeer, and even a mammoth, executed with considerable skill on bone, reindeer-horns, and mammoth-tusks. These, taken together, indicate a state of civilization much higher than that of the lowest of our modern savages, while it is quite compatible with a considerable degree of mental advancement, and leads us to believe that the crania of Engis and Cro-Magnon are not exceptional, but fairly represent the characters of the race. If we further remember that these people lived in Europe under the unfavorable conditions of a sub-Arctic climate, we shall be inclined to agree with Dr. Daniel Wilson, that it is far easier to produce evidences of deterioration than of progress in instituting a comparison between the contemporaries of the mammoth and later prehistoric races of Europe or savage nations of modern times.*

3. Yet another important line of evidence as to the extreme antiquity of the human type has been brought prominently forward by Prof. Mivart.† He shows by a careful comparison of all parts of the structure of the body, that man is related, not to any one, but almost equally to many of the existing apes—to the orang, the chimpanzee, the gorilla, and even to the gibbons—in a variety of ways; and these relations and differ-

* "Prehistoric Man," 3d ed., vol. i, p. 117.

† "Man and Apes," pp. 171–193.

ences are so numerous and so diverse that on the theory of evolution the ancestral form which ultimately developed into man must have diverged from the common stock whence all these various forms and their extinct allies originated. But so far back as the Miocene deposits of Europe, we find the remains of apes allied to these various forms, and especially to the gibbons, so that in all probability the special line of variation which led up to man branched off at a still earlier period. And these early forms, being the initiation of a far higher type, and having to develop by natural selection into so specialized and altogether distinct a creature as man, must have risen at a very early period into the position of a dominant race, and spread in dense waves of population over all suitable portions of the great continent—for this, on Mr. Darwin's hypothesis, is essential to rapid developmental progress through the agency of natural selection.

Under these circumstances we might certainly expect to find some relics of these earlier forms of man along with those of animals which were presumably less abundant. Negative evidence of this kind is not very weighty, but still it has *some* value. It has been suggested that as apes are mostly tropical, and the anthropoid apes are now confined almost exclusively to the vicinity of the equator, we should expect the ancestral forms also to have inhabited these same localities—West Africa and the Malay islands. But this objection is hardly valid, because existing anthropoid apes are wholly dependent on a perennial supply of easily accessible fruits, which is only found near the equator, while not only had the south of Europe an almost tropical climate in Miocene times, but we must suppose even the earliest ancestors of man to have been terrestrial and omnivorous, since it must have taken ages of slow modification to have produced the perfectly erect form, the short arms, and the wholly non-prehensile foot, which so strongly differentiate man from the apes.

The conclusion which I think we must arrive at is, that if man has been developed from a common ancestor, with all existing apes, *and by no other agencies than such as have affected their development*, then he must have existed in something approaching his present form, during the tertiary period—and not merely existed, but predominated in numbers, wherever suitable conditions prevail. If then continued researches in all parts of Europe and Asia fail to bring to light any proofs of his presence, it will be at least a presumption that he came into existence at a much later date, and by a much more rapid process of development. In that case it will be a fair argument, that, just as he is in his mental and moral nature, his capacities and aspirations, so infinitely raised above the brutes, so his

origin is due to distinct and higher agencies than such as have affected their development.

There is yet another line of inquiry bearing upon this subject to which I wish to call your attention. It is a somewhat curious fact, that, while all modern writers admit the great antiquity of man, most of them maintain the very recent development of his intellect, and will hardly contemplate the possibility of men equal in mental capacity to ourselves, having existed in prehistoric times. This question is generally assumed to be settled, by such relics as have been preserved of the manufactures of the older races showing a lower and lower state of the arts; by the successive disappearance in early times of iron, bronze, and pottery; and by the ruder forms of the older flint implements. The weakness of this argument has been well shown by Mr. Albert Mott in his very original, but little known presidential address to the Literary and Philosophical Society of Liverpool in 1873. He maintains that "our most distant glimpses of the past are still of a world peopled as now with men both civilized and savage"—and, "that we have often entirely misread the past by supposing that the outward signs of civilization must always be the same, and must be such as are found among ourselves." In support of this view he adduces a variety of striking facts and ingenious arguments, a few of which I will briefly summarize.

On one of the most remote islands of the Pacific—Easter Island—2,000 miles from South America, 2,000 from the Marquesas, and more than 1,000 from the Gambier Islands, are found hundreds of gigantic stone images, now mostly in ruins, often thirty or forty feet high, while some seem to have been much larger, the crowns on their heads cut out of a red stone being sometimes ten feet in diameter, while even the head and neck of one is said to have been twenty feet high.* These once stood erect on extensive stone platforms, yet the island has only an area of about thirty square miles, or considerably less than Jersey. Now as one of the smallest images eight feet high weighs four tons, the largest must weigh over a hundred tons, if not much more; and the existence of such vast works implies a large population, abundance of food, and an established government. Yet how could these coexist in a mere speck of land wholly cut off from the rest of the world? Mr. Mott maintains that this necessarily implies the power of regular communication with larger islands or a continent, the arts of navigation, and a civilization much higher than now exists in any part of the Pacific. Very similar remains in other islands scattered widely over the Pacific add weight to this argument.

* Journ. of Roy. Geog. Soc., 1870, pp. 177, 178.

The next example is that of the ancient mounds and earthworks of the North American continent, the bearing of which is even more significant. Over the greater part of the extensive Mississippi valley four well-marked classes of these earthworks occur. Some are camps, or works of defence, situated on bluffs, promontories, or isolated hills; others are vast inclosures in the plains and lowlands, often of geometric forms, and having attached to them roadways or avenues often miles in length; a third are mounds corresponding to our tumuli, often seventy to ninety feet high, and some of them covering acres of ground; while a fourth group consist of representations of various animals modelled in relief on a gigantic scale, and occurring chiefly in an area somewhat to the north-west of the other classes, in the plains of Wisconsin.

The first class—the camps or fortified inclosures—resemble in general features the ancient camps of our own islands, but far surpass them in extent. Fort Hill, in Ohio, is surrounded by a wall and a ditch a mile and a half in length, part of the way cut through solid rock. Artificial reservoirs for water were made within it, while at one extremity, on a more elevated point, a keep is constructed with its separate defences and water-reservoirs. Another, called Clark's Work, in the Scioto valley, which seems to have been a fortified town, incloses an area of 127 acres, the embankments measuring three miles in length, and containing not less than three million cubic feet of earth. This area incloses numerous sacrificial mounds and symmetrical earth-works in which many interesting relics and works of art have been found.

The second class—the sacred inclosures—may be compared for extent and arrangement with Avebury or Carnak—but are in some respects even more remarkable. One of these, at Newark, Ohio, covers an area of several miles with its connected groups or circles, octagons, squares, ellipses, and avenues, on a grand scale, and formed by embankments from twenty to thirty feet in height. Other similar works occur in different parts of Ohio, and by accurate survey it is found not only that the circles are true, though some of them are one-third of a mile in diameter, but that other figures are truly square, each side being over 1,000 feet long, and, what is still more important, the dimensions of some of these geometrical figures in different parts of the country and seventy miles apart are identical. Now this proves the use, by the builders of these works, of some standard measures of length, while the accuracy of the squares, circles, and, in a less degree, of the octagonal figures—shows a considerable knowledge of rudimentary geometry, and some means of measuring angles. The difficulty of drawing such figures on a large scale is much

greater than any one would imagine who has not tried it, and the accuracy of these is far beyond what is necessary to satisfy the eye. We must therefore impute to these people the wish to make these figures as accurate as possible, and this wish is a greater proof of habitual skill and intellectual advancement than even the ability to draw such figures. If, then, we take into account this ability and this love of geometric truth, and further consider the dense population and civil organization implied by the construction of such extensive systematic works we must allow that these people had reached the earlier stages of a civilization of which no traces existed among the savage tribes who alone occupied the country when first visited by Europeans.

The animal mounds are of comparatively less importance for our present purpose, as they imply a somewhat lower grade of advancement; but the sepulchral and sacrificial mounds exist in vast numbers, and their partial exploration has yielded a quantity of articles and works of art, which throw some further light on the peculiarities of this mysterious people. Most of these mounds contain a large concave hearth or basis of burnt clay, of perfectly symmetrical form, on which are found deposited more or less abundant relics, all bearing traces of the action of fire. We are, therefore, only acquainted with such articles as are practically fire-proof. These consist of bone and copper implements and ornaments, discs, and tubes—pearl, shell and silver beads, more or less injured by the fire—ornaments cut in mica, ornamental pottery, and numbers of elaborate carvings in stone, mostly forming pipes for smoking. The metallic articles are all formed by hammering, but the execution is very good; plates of mica are found cut into scrolls and circles; the pottery, of which very few remains have been found, is far superior to that of any of the Indian tribes, since Dr. Wilson is of opinion that they must have been formed on a wheel, as they are often of uniform thickness throughout (sometimes not more than one sixth of an inch) polished, and ornamented with scrolls and figures of birds and flowers in delicate relief. But the most instructive objects are the sculptured stone pipes, representing not only various easily recognizable animals, but also human heads, so well executed that they appear to be portraits. Among the animals, not only are such native forms as the panther, bear, otter, wolf, beaver, raccoon, heron, crow, turtle, frog, rattlesnake, and many others, well represented, but also the manatee, which perhaps then ascended the Mississippi as it now does the Amazon, and the toucan, which could hardly have been obtained nearer than Mexico. The sculptured heads are especially remarkable, because they present to us the features of an intellectual and civilized people. The nose in some is perfectly straight, and

neither prominent nor dilated, the mouth is small, and the lips thin, the chin and upper lip are short, contrasting with the ponderous jaw of the modern Indian, while the cheek-bones present no marked prominence. Other examples have the nose somewhat projecting at the apex in a manner quite unlike the features of any American indigenes, and, although there are some which show a much coarser face, it is very difficult to see in any of them that close resemblance to the Indian type which these sculptures have been said to exhibit. The few authentic crania from the mounds present corresponding features, being far more symmetrical and better developed in the frontal region than those of any American tribes, although somewhat resembling them in the occipital outline;* while one was described by its discoverer (Mr. W. Marshall Anderson) as "a beautiful skull worthy of a Greek."

The antiquity of this remarkable race may perhaps not be very great, as compared with the prehistoric man of Europe, although the opinions of some writers on the subject seem affected by that "parsimony of time" on which the late Sir Charles Lyell so often dilated. The mounds are all overgrown with dense forest, and one of the large trees was estimated to be eight hundred years old, while other observers consider the forest growth to indicate an age of at least 1,000 years. But it is well known that it requires several generations of trees to pass away before the growth on a deserted clearing comes to correspond with that of the surrounding virgin forest, while this forest, once established, may go on growing for an unknown number of thousands of years. The 800 or 1,000 years' estimate from the growth of existing vegetation is a minimum which has no bearing whatever on the actual age of these mounds, and we might almost as well attempt to determine the time of the glacial epoch from the age of the pines or oaks which now grow on the moraines.

The important thing for us, however, is that when North America was first settled by Europeans, the Indian tribes inhabiting it had no knowledge or tradition of any preceding race of higher civilization than themselves. Yet we find that such a race existed; that they must have been populous and have lived under some established government; while there are signs that they practised agriculture largely, as indeed they must have done to have supported a population capable of executing such gigantic works in such vast profusion—for it is stated that the mounds and earthworks of various kinds in the State of Ohio alone amount to between eleven and twelve thousand. In their habits, customs, religion, and arts, they differed strikingly from all the Indian tribes; while their love

* Wilson's "Prehistoric Man," 3d ed., vol. ii, pp. 123–130.

of art and of geometric forms, and their capacity for executing the latter upon so gigantic a scale, render it probable that they were a really civilized people, although the form their civilization took may have been very different from that of later people subject to very different influences, and the inheritors of a longer series of ancestral civilizations. We have here, at all events, a striking example of the transition, over an extensive country, from comparative civilization to comparative barbarism, the former having left no tradition, and hardly any trace of influence on the latter.

As Mr. Mott well remarks :—Nothing can be more striking than the fact that Easter Island and North America both give the same testimony as to the origin of the savage life found in them, although in all circumstances and surroundings the two cases are so different. If no stone monuments had been constructed in Easter Island, or mounds, containing a few relics saved from fire, in the United States, we might never have suspected the existence of these ancient peoples. He argues, therefore, that it is very easy for the records of an ancient nation's life entirely to perish, or to be hidden from observation. Even the arts of Nineveh and Babylon were unknown only a generation ago, and we have only just discovered the facts about the mound-builders of North America.

But other parts of the American continent exhibit parallel phenomena. Recent investigations show that in Mexico, Central America, and Peru, the existing race of Indians has been preceded by a distinct and more civilized race. This is proved by the sculptures of the ruined cities of Central America, by the more ancient terra-cottas and paintings of Mexico, and by the oldest protrait-pottery of Peru. All alike show markedly non-Indian features, while they often closely resemble modern European types. Ancient crania, too, have been found in all these countries, presenting very different characters from those of any of the modern indigenous races of America.*

There is one other striking example of a higher being succeeded by a lower degree of knowledge, which is in danger of being forgotten because it has been made the foundation of theories which seem wild and fantastic, and are probably in great part erroneous. I allude to the Great Pyramid of Egypt, whose form, dimensions, structure, and uses have recently been the subject of elaborate works by Professor Piazzi Smyth. Now, the admitted fact about this pyramid are so interesting and so apposite to the subject we are considering, that I beg to recall them to your attention. Most of you are aware that this pyramid has been carefully explored and measured by successive Egyptologists, and that the dimensions have lately become

* Wilson's "Prehistoric Man," 3d ed., vol. ii, pp. 125, 144.

capable of more accurate determination owing to the discovery of some of the original casing-stones and the clearing away of the earth from the corners of the foundation, showing the sockets in which the corner-stones fitted. Professor Smyth devoted many months of work with the best instruments in order to fix the dimensions and angles of all accessible parts of the structure; and he has carefully determined these by a comparison of his own and all previous measures, the best of which agree pretty closely with each other. The results arrived at are—

1. That the pyramid is truly square, the sides being equal and the angles right angles.

2. That the four sockets on which the four first stones of the corners rested are truly on the same level.

3. That the direction of the sides are accurately to the four cardinal points.

4. That the vertical height of the pyramid bears the same proportion to its circumference at the base, as the radius of a circle does to its circumference.

Now all these measures, angles, and levels are accurate, not as an ordinary surveyor or builder could make them, but to such a degree as requires the very best modern instruments and all the refinements of geodetical science to discover any error at all. In addition to this we have the wonderful perfection of the workmanship in the interior of the pyramid, the passages and chambers being lined with huge blocks of stones fitted with the utmost accuracy, while every part of the building exhibits the highest structural science.

In all these respects this largest pyramid surpasses every other in Egypt. Yet it is universally admitted to be the oldest, and also the oldest historical building in the world.

Now these admitted facts about the Great Pyramid are surely remarkable, and worthy of the deepest consideration. They are facts which, in the pregnant words of the late Sir John Herschel, "according to received theories ought not to happen," and which, he tells us, should therefore be kept ever present to our minds, since "they belong to the class of facts which serve as the clue to new discoveries." According to modern theories, the higher civilization is ever a growth and an outcome from a preceding lower state; and it is inferred that this progress is visible to us throughout all history and in all the material records of human intellect. But here we have a building which marks the very dawn of history—which is the oldest authentic monument of man's genius and skill, and which, instead of being far inferior, is very much superior to all which followed it. Great men are the products of their age and country, and the designer and constructors of this wonderful monument

could never have arisen among an unintellectual and half-barbarous people. So perfect a work implies many preceding less perfect works which have disappeared. It marks the culminating point of an ancient civilization, of the early stages of which we have no record whatever.

The three cases to which I have now adverted (and there are many others) seem to require for their satisfactory interpretation a somewhat different view of human progress from that which is now generally accepted. Taken in connection with the great intellectual power of the ancient Greeks—which Mr. Galton believes to have been far above that of the average of any modern nation—and the elevation, at once intellectual and moral, displayed in the writings of Confucius, Zoroaster, and the Vedas, they point to the conclusion, that, while in material progress there has been a tolerably steady advance, man's intellectual and moral development reached almost its highest level in a very remote past. The lower, the more animal, but often the more energetic types, have however always been far the more numerous; hence such established societies as have here and there arisen under the guidance of higher minds, have always been liable to be swept away by the incursions of barbarians. Thus in almost every part of the globe there may have been a long succession of partial civilization, each in turn succeeded by a period of barbarism; and this view seems supported by the occurrence of degraded types of skull along with such "as might have belonged to a philosopher"—at a time when the mammoth and the reindeer inhabited southern France.

Nor need we fear that there is not time enough for the rise and decay of so many successive civilizations as this view would imply; for the opinion is now gaining ground among geologists that paleolithic man was really preglacial, and that the great gap—marked alike by a change of physical conditions, and of animal life—which in Europe always separates him from his neolithic successor, was caused by the coming on and passing away of the great ice age.

If the views now advanced are correct, many, perhaps most, of our existing savages, are the successors of higher races; and their arts, often showing a wonderful similarity in distant continents, may have been derived from a common source among more civilized peoples.

I must now conclude this very imperfect sketch of a few of the offshoots from the great tree of Biological study. It will, perhaps, be thought by some that my remarks have tended to the depreciation of our science, by hinting at imperfections in our knowledge and errors in our theories, where more enthusiastic students see nothing but established truths. But I trust that I may have conveyed to many of my hearers a different

impression. I have endeavored to show that even in what are usually considered the more trivial and superficial characters presented by natural objects, a whole field of new inquiry is opened up to us by the study of distribution and local conditions. And as regards man, I have endeavored to fix your attention on a class of facts which indicate that the course of his development has been far less direct and simple than has hitherto been supposed; and that, instead of resembling a single tide with its advancing and receding ripples, it must rather be compared to the progress from neap to spring tides, both the rise and the depression being comparatively greater as the waters of true civilization slowly advance towards the highest level they can reach.

And if we are thus led to believe that our present knowledge of nature is somewhat less complete than we have been accustomed to consider it, this is only what we might expect; for however great may have been the intellectual triumphs of the nineteenth century, we can hardly think so highly of its achievements as to imagine that, in somewhat less than twenty years, we have passed from complete ignorance to almost perfect knowledge on two such vast and complex subjects as the origin of species and the antiquity of man.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Pyrogenic Hydrocarbons in Coal Gas.*—Berthelot has made a study of the hydro-carbons in coal gas, which tends to confirm his theory of the formation of these bodies by the action of acetylene and hydrogen at high temperatures. In the Paris gas for example, he finds that he can detect benzene by exposing two or three cubic centimeters to a drop of fuming nitric acid. On diluting with water, the characteristic odor of nitrobenzene appears. Fifty liters of gas passed through 8 or 10 c.c. of the acid, gives enough nitrobenzene when diluted, to weigh; from which it appears that the gas contains two or three volumes of benzene vapor in the hundred. More accurate determination gives 3 to 3·5 volumes. Next to methane, therefore, benzene is the principal hydrocarbon in this gas and is the illuminant, *par excellence.* Ethylene and acetylene, though present, exist in minute proportion, only two to three thousandths. Propylene, butylene, and allylene are found, in amount about two-tenths per cent. They were detected by passing the gas first through sulphuric acid diluted with its own volume of water, and then through a column of pumice stone wet with concentrated sulphuric acid. A tarry substance collected in the first vessel, which yielded

no products volatile below 360°–400°, and was probably composed of polymers of some easily alterable hydrocarbon. The acid itself, fractionated, gave acetone, 0·25 gram per 100 cubic meters, coming from the hydration of allylene. The sulphuric acid collected beneath the pumice column gave two layers. The lower one consisted of the acid, more or less altered. Diluted with water, a tarry substance of high boiling point separated, probably polymerized hydrocarbons. The acid liquid gave isopropyl alcohol on distillation, thus proving the existence of propylene. The upper layer of liquid, in amount about 25 grams to 100 cubic meters of gas, consisted of hydrocarbons, and gave on fractioning, benzene (with a little toluene) 2 per cent, mesitylene (C_9H_{12}) 5 per cent, cymene ($C_{10}H_{14}$) 20 per cent, tricrotonylene ($C_{12}H_{18}$) 30 per cent, colophene ($C_{15}H_{24}$) 32 per cent, residue fixed at 320° 5 per cent, intermediate products and loss 6 per cent =100. In one million volumes of this gas, consequently, there are by this analysis:

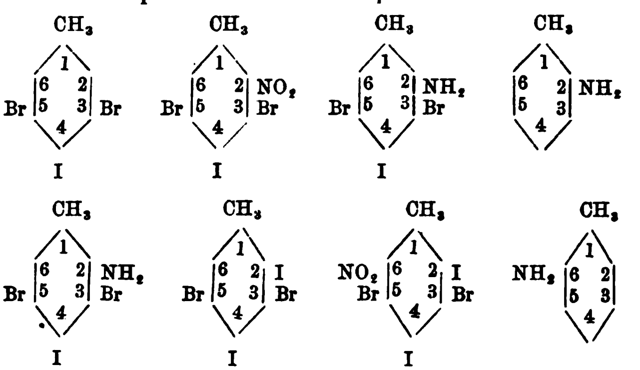
Benzene (C_6H_6) in vapor	30000 to 35000	
Acetylene (C_2H_2)	1000 (about)	
Ethylene (C_2H_4)	1000 to 2000	
Propylene (C_3H_6)	2·5	
Allylene (C_3H_4)	8	
Butylene (C_4H_8) and analogues	traces	
Crotonylene (C_4H_6)	31	181
Terene (C_5H_8)	12	
Hydrocarb's transfor'd into fixed polymers, est'd	83	
Diacetylene and analogous hydrocarbons, est'd	15	

The author regards these products as derived according to the reactions upon which he founds his theory, from the four fundamental hydrocarbons acetylene C_2H_2, ethylene C_2H_4, dimethyl C_2H_6, and methane CH_4. These, together with hydrogen forming a system in equilibrium, such that, at a red heat they are all formed from any one of them as the starting point. Thus from methane comes directly ethylene (C_2H_4) or $(CH_2)_2$, propylene $(CH_2)_3$ and the series of polymers $(CH_2)_n$. Acetylene produces benzene C_6H_6 or $(C_2H_2)_3$, and the series of polymers $(C_2H_2)_n$. Moreover, from the union of two of these fundamental hydrocarbons, more complex bodies come: acetylene and benzene giving styrolene C_8H_8; acetylene and styrolene, naphthalene $C_{10}H_8$; acetylene and naphthalene, acenaphthene $C_{12}H_{10}$; and styrolene and benzene, anthracene $C_{14}H_{10}$. So acetylene combines at a dull red heat with ethylene to form ethylacetylene C_4H_6, and with propylene to yield propylacetylene C_5H_8, the former identical with crotonylene, the latter with terene. The uselessness of the present eudiometric method of determining the illuminants in gas analysis is obvious from these results.—*Bull. Soc. Ch.*, II, xxvi, 104, Aug., 1876. G. F. B.

2. *Occurrence of Benzene in Rosin Oil.*—Watson Smith has examined the light oils obtained as a bye-product in the refining

of rosin by distillation in a current of super-heated steam. In 1867, he examined a sample which began to boil at 50° and which distilled almost completely below 100°. On fractioning, a liquid was obtained boiling between 80° and 85° which had the properties of benzene, though contaminated with turpentine-products. Meantime changes had been made in the works, a much higher temperature being employed. A sample from the first run of the rectifying still, examined in 1875, began to boil at 109°, and to condense at 116°. When fractionated, toluene was the substance of lowest boiling point obtained. Hence the temperature of distillation determines the products.—*J. Chem. Soc.*, II, xxx, 29, July, 1876. G. F. B.

3. *On the Constitution of the Benzene Derivatives.*—Wroblewsky described in 1875 two metabromtoluenes having identical properties, in one of which the methyl and the bromine atoms occupied the 1 : 3 position according to Kekulé's theory, in the other the 1 : 5 position. He now describes two ortho-toluidines having the methyl and amidogen groups respectively in the positions 1 : 2 and 1 : 6. Starting with dibromparatoluidine, in which the two bromine atoms occupy the positions 3 and 5, the methyl and amidogen groups 1 and 4, the author replaced the amidogen by iodine, thus forming $C_7H_5Br_2I$, dibromparaiodtoluene. By the action of fuming nitric acid a nitroderivative $C_7H_4Br_2INO_2$ was obtained, in which the nitryl must occupy the position 2 or the position 6. On reduction with tin and hydrochloric acid this gave $C_7H_4Br_2INH_2$, and this by the action of sodium amalgam gave orthotoluidine, $C_7H_7NH_2$. For the second substance, the meta-dibrom-paraiod-ortho-toluidine was converted by the method of Griess into $C_7H_4Br_2I_2$ dibrom-diiod-toluene. This gave a nitro-derivative $C_7H_3Br_2I_2NO_2$, in which the nitryl must occupy the position 6 if the former had 2; or the reverse. By reducing the amido-product obtained from this with sodium amalgam, a second ortho-toluidine was obtained, identical in properties with the former, thus adding a new confirmation to Kekulé's theory. The progress of the replacements is thus represented:



—*Ber. Berl. Chem. Ges.*, ix, 1055, July, 1876. G. F. B.

4. *On the Action of Malt-extract on Starch.*—O'SULLIVAN has examined more fully the conditions under which malt-extract acts on starch. He formulates his conclusions as follows: (1) Maltose and dextrin are the only products of the action of malt-extract on starch. (2) Cold malt-extract does not act on ungelatinized starch. (3) Malt-extract begins to dissolve starch at the temperature of gelatinization or a few degrees lower. (4) Malt-extract dissolves gelatinized starch in the cold, (10° to 20°) almost completely if the gelatinization be perfect. (5) When starch is dissolved by malt-extract at any temperature below 63°, if the solution be immediately (5 or 10 minutes) cooled and filtered, the product invariably contains maltose and dextrin in proportions agreeing closely with 67·85 per cent of the former, and 32·15 per cent of the latter. (6) If the temperature of the action be between 64° and 68°–70°, the maltose present is 34·54 per cent and the dextrin 65·46 per cent. (7) If the temperature be between 68° and 70° and the point at which the activity of the transforming agent is destroyed, the maltose and dextrin are in the proportion of 17·4 to 82·6 per cent. The decomposition of starch into maltose and dextrin is molecular and takes place according to three equations, corresponding to the conditions in (5), (6) and (7) above. Dextrin is converted into maltose by a slow and gradual process of hydration. —*J. Chem. Soc.*, xxx, 125, Aug., 1876. G. F. B.

5. *Detection of Carbamic acid in Animal fluids.*—HOFMEISTER has examined the evidence upon which Drechsel based his assertion that carbamic acid is produced wherever nitrogenous substances are oxidized in alkaline solutions, and hence exists in the blood. He finds that the reactions upon which Drechsel based his opinion are untrustworthy, inasmuch as the production of a precipitate on boiling, after having filtered off the precipitate produced by calcium nitrate, cannot be taken as proof of the existence of carbamic acid.—*J. pr. Ch.*, II, xiv, 173, Aug., 1876. G. F. B.

6. *Friction of Gases.*—M. WIEDEMANN has measured the changes in the coefficients of friction of gases with changes in the temperature by a new form of apparatus. In a recent paper on the specific heat of gases he claims that a gas undergoes a sort of dissociation upon a change of temperature and that the diameter of the molecules ought not to vary with the temperature according to the same law as if the gas was not decomposed. Moreover, according to the new theory of gases, the coefficient of friction of gases gives a relative measure of the diameter of its molecules. The gas is contained in two glass bulbs 7·3 cms. in diameter and and 4·5 cms. high. One is placed above the other and they are connected by a glass tube ·8 cms. in diameter and 15 cms. long. They are enclosed in a case with glass sides which may be filled with water. Each bulb contains in the prolongation of the tube connecting them, a small orifice. To the lower one is connected a three-way cock with two horizontal tubes. One of these tubes is connected with a reservoir of mercury of variable height, by which mercury may be admitted into the bulbs. The other tube

allows the mercury to pass out. The upper bulb is connected with a water manometer and drying tube and with a capillary tube. The latter is attached to a larger tube 1·8 cms. in diameter and 4·8 cms. long, filled with copper turnings by which the gas is brought to any required temperature before entering the capillary. Both these tubes can be immersed in a vessel of cold water or in a tube with a double wall in which circulates the vapor of aniline or water.

To make the experiment the end of the capillary tube is closed until the top of the mercurial column stands near a point marked on the vertical tube. The capillary is then opened and at the instant the mercury passes the mark, a stop-watch is started and the pressure read by the manometer. This pressure is maintained constant during the whole experiment by slowly raising the mercury reservoir. At the end of 5 to 15 minutes the mercury supply is cut off and that in the bulbs is drawn off until it stands at the level of the mark. The weight of mercury gives the volume of gas transpired. The following table gives the result of the measurement of six gases at temperatures, 8°, 100° and 184·5°. The first column gives the name of the gas, the next three the coefficients of friction at 100° and 184·5° taking the coefficient of air as 100. The last two columns give the friction compared with that of air at 8°.

	0°	100°	184·5°	100°	184·5°
Air	100	100	100	123·1	141·1
Carbonic oxide	96·87	----	96·42	----	136·0
Carbon acid	80·5	85·63	87·50	104·8	123·4
Protoxide nitrogen	80·5	85·82	87·94	105·6	124·1
Ethylene	56·24	60·02	61·93	73·89	87·38
Hydrogen	51·51	51·81			

It is commonly assumed that the friction is proportional to some power n of the absolute temperature. But a computation with the above values shows that no value of n will satisfy all the observations.—*Bib. Univ.*, ccxxiii, 277. E. C. P.

7. *Effect of Sound on the Radiometer.*—M. Jeannel has observed that certain sonorous vibrations cause rotatory movements in the radiometer. In half obscurity, three radiometers were placed on the interior tablet of a chamber organ. The bass notes, those of the three first octaves, produced rotation, the most bass acting most, but *fa* and *fa* sharp of the lower octave (especially with the bourdon stop) produced more rapid rotation than *ut*, *re* and *mi*, though these are more grave. Radiometers do not all act in the same manner, as to rapidity and direction of their rotation. Thus to the low *fa* or *fa* sharp, radiometer A, the less sensitive to light made about one turn per second. The black faces first (i. e. a direction opposite to that produced by light), whilst radiometers B and C, which were more sensitive to light, turned more slowly in the direction of the movement produced by light. M. Jeannel explains these effects by circular or angular vibrations of the supporting needle transmitted from the tablet of the organ. By applying the finger to the top of the radiometer,

one may prevent the vibration and also the rotation. The board of a piano produces similar effects but in a less degree. If the experiments be made where the diffuse light is nearly sufficient to drive the radiometer, grave sounds, even the weakest, cause rotation in the ordinary direction (bright surfaces first); the rumble of a vehicle will suffice. Here the light is at first insufficient to overcome the friction, but when the vibrations intervene, friction is lessened during certain intervals, and the apparatus is thus rendered more sensitive to light.—*Nature*, xiv, 419. E. C. P.

8. *Fusion of Soft Bodies.*—M. PFAUNDLER has presented to the Imperial Academy of Sciences at Vienna, papers on the nature of the soft or half liquid state of aggregation, and on regelation and recrystallization. After dividing the bodies in question into mixtures of small solid parts with true liquids, soft bodies proper, containing no dissimilar parts, and mixtures of the two classes, he gives a hypothesis on the process of melting and the soft state. The common ideal melting process, when the temperature remains the same from the beginning to the end is not according to fact. The mean temperature of the body beginning to melt is about $t+t'$ lower than that of the already melted mass, if $\pm t$ and $\pm t'$ denote the amounts of divergence of temperature of the separate molecules in the solid and liquid condition. Hence the true melting point is different from that at the beginning, and the end of the melting process. M. Pfaundler extends his hypothesis to soft bodies of a compound nature, and to regelation and recrystallization.—*Nature*, xiv, 383. E. C. P.

9. *Friction of Gases.*—Professor KUNDT, in a popular lecture on "the Modern Theory of Gases," delivered last March in Berlin, made an ingenious application of the principle of the radiometer. Having first shown the friction of air of ordinary density by means of a rotating disk, the lecturer then took an exhausted vessel containing two disks, each about three centimeters in diameter supported very close to one another; the lower one had the usual vanes of the radiometer while the upper one had only a couple of small projecting wires sufficient to show its motion. A magnesium lamp served for projecting the instrument on a screen, and to rotate the lower disk; through the minute amount of air remaining in the vessel the upper disk was put promptly into rotation.

Probably the same principle will find other applications when rotation in a vacuum is to be produced. C. K. W.

10. *On the Electro-magnetic action of Electric Convection;* by Dr. HELMHOLTZ. A report on some experiments carried out by Mr. Henry A. Rowland, of the Johns Hopkins University, in Baltimore.—I understand by electric convection the conveyance of electricity by the motion of its ponderable bearers. In my last memoir on the theory of electro-dynamics,* I proposed some experiments (which were then carried out by Herr N. Schiller) in which the question came into consideration whether electric convection is dynamically equivalent to the flow of electricity in a

* *Monatsbericht* of the Berlin Academy of Sciences, June 17, 1875, p. 405.

conductor, as W. Weber's theory assumes. Those experiments might possibly have been decisive against the existence of such an action. They were not so; but, on the other hand, through this negative result the existence of the action in question remained unproved. Mr. Rowland has now carried out a series of direct experiments, in the physical laboratory of the University here, which give positive proof that the motion of electrified ponderable substances is also electro-magnetically operative. I here remark that he had already conceived and fully considered the plan of his experiments when he came to Berlin, without any previous coöperation on my part.

The moved bearer of the electricity was a disk of ebonite 21·1 centims. in diameter and ½ centim. thick. It could revolve with great velocity (up to 61 times in a second) about a vertical axis fixed in its center. The ebonite disk was gilt on both sides; but the gilding was insulated from the axis. Near it, above and below, were placed glass disks of 38·9 centims. diameter, pierced through the middle to admit the axis of the ebonite disk. The glass disks were likewise gilt, in an annular band of 24 centims. external, 8·9 internal diameter; the gilt side was mostly turned toward the ebonite disk. The gilt surfaces of the glass disks were, as a rule, connected to earth; while the ebonite between them, through a point directed toward it at a distance of ½ millim. from its margin, was in electrical communication with the coatings of a large insulated Leyden battery which served as a reservoir for the electricity. A commutator of a peculiar construction, inserted between them, permitted now the one, now the other coating to be connected either with the ebonite disk or with the earth. In the construction of these parts, iron was avoided.

Close above the upper glass disk an extremely sensitive astatic needle was suspended to an arm fixed in the wall, and completely enclosed in a brass case connected to earth. The two needles were 1·5 centim. long, but at a considerable distance (17·98 centims.) from each other. Their deflections were read off with a mirror and a telescope. The opening in front of the mirror was protected from external electrical influences by a metallic hollow cone. Indeed the electrical charge of the battery and the reversal of the electrification of the ebonite disk gave no perceptible trace of action on the needle so long as the ebonite was stationary.

On the other hand, on swift rotation, even without electrifying, the action of rotation-magnetism was shown, mostly arising from the brass axis of the rotating disk, and considerably diminished by reducing it to 0·9 centim. thickness. The action of the electrification of the disk could be separated from that of the rotation-magnetism by letting in alternately positive and negative electricity (by means of the commutator above-mentioned) while the velocity of the rotation was maintained unaltered. The displacement of the needle from the position of equilibrium amounted to from 5 to 7½, its arc of oscillation on changing the electrification, therefore, to from 10 to 15 scale-divisions. This result ensued in hundreds of

observations (which were made with gradually and continually more and more improved apparatus in the course of several weeks), and always in the same direction. The direction of the deflection of the needle, the length of which was normal to the radius of the disk, was such as would have been produced by a positive electric current flowing with the rotation of the positively charged disk, or against the rotation of the disk charged negatively.

There was no alteration in the action when the gilding of the ebonite plate was removed in a series of radial lines, so that annular electric currents could no longer take place. A thin plate of glass was also inserted instead of the gilt ebonite, and, like the disk of a Holtz machine, could be electrified through points; while close beneath it there was a gilt resting plate connected to earth, in order to fix as much electricity as possible. The direction of the deflections was the same as in the previous experiments: but they were smaller, as the conditions were not so favorable for strong electrification.

In order to compare the electricity carried forward by convection with that which passes in conductors, experiments were instituted in the following manner.

The ebonite disk was gilded afresh, and the gold coating divided, by a series of fine circular lines, into rings insulated from one another. The innermost ring was connected with the axis; the rest could not at any rate become considerably charged without discharging themselves by very short sparks from one to the other. Two electrified plates, each having the form of a sector of a circle, but which did not reach to the axis, were placed, opposite to one another, above and below the rotating plate. Under these circumstances the electricity of the gold rings must have been accumulated by electrostatic induction in the sector covered by the last-mentioned plates, and carried forward convectively. When this electricity was positive, it became free at the fore margin of the induced sector (in the direction of the rotation), while at the hind margin of the same, continually new positive electricity being attached, relatively negative electricity became free.

The positive electricity must, under these conditions, have overflowed from the fore to the hind margin of the sector, for which there were in each ring two paths open, between which it must have divided itself in the inverse ratio of their resistances. If the inducing sector comprises $\frac{1}{n}$ of the circumference, the resistance of the path in the sector is to that of the path outside of it as $1 : n-1$; and therefore $\frac{n-1}{n}$ of the current returns through the sector, and $\frac{1}{n}$ outside of it. In the sector a quantity corresponding to the sum of the two currents is carried forward against the current by convection. If, then, a convective motion of electricity

acts like a conducted motion, the total motion in the sector is $1-\frac{n-1}{n}=\frac{1}{n}$. But if the action of convective had been greater or less than that of conducted motion, the excess, in one or the other direction, must have been shown on the sector.

The experiments showed that, when the sector was small ($\frac{1}{8}$ of the circumference), the small difference between the convection 1 and the conduction $\frac{7}{8}$ in general could not (or at least not with certainty) be detected, that therefore, with approximate equality of convection and conduction, the electro-dynamic effect of the one sensibly neutralized that of the other.

When, however, the sector took in half of the circumference, the here assumed current could be observed even in the free portion of the disk, though the amount was too small for safe measurement.

The observed electro-dynamic action being so little in the foregoing experiments, in which the disk was electrified and covered in its whole extent by the induced plates, theoretical calculation of the amount of the action from the known absolute values of the electro-dynamic constants promised only approximately accordant values. Nevertheless it was carried out by Mr. Rowland.

The proportion in which the action of the earth's magnetism upon the pair of astatic needles was diminished was ascertained by finding the oscillation-period, first with the needles equally directed, and then arranged astatically.

The value of the function of the electric potential in the Leyden battery, and on the rotating disk, was determined according to the law of spark-length given by Sir William Thomson, which in this case appeared sufficiently accurate. Before and after each experiment, a smaller jar was charged from the battery of nine large ones containing the store of electricity, and on it the length of the spark was determined.

The velocity of the rotation was regulated by the position of the balls of a centrifugal governor, which was applied to one of the more slowly rotating axes. The calculation from the magnitude of the rollers agreed well with the determination by the tone of a siren-disk, which was for some time attached to the most rapidly revolving axis.

In the calculation of the distribution of the electricity on the disk, and its electro-magnetic directing-force, the surplus charge present at the margin of the disk was reckoned according to the value which holds for infinitely thin disks, and considered as an infinitely thin thread concentrated at the margin—a proceeding which was in both ways only approximately correct, but, in presence of the minuteness of this portion, was sufficient.

The influence exerted upon the upper needle was about $\frac{1}{50}$ of that upon the lower. The horizontal force of the earth's magnetism was put equal to 0·182 (using the centimeter, gram, and second as units): the electro-dynamic constant was put by Mr.

Rowland, after Maxwell's determinations, equal to 28,800 millions. W. Weber's value would be 31,074 millions. I give below under M. the results calculated with the former value, under W. those calculated with the latter.

The following is the result of the calculation of only three series of experiments conducted under favorable circumstances:—

(1) Ten experiments with alternately opposite rotation. In each, three readings, of which the middle one was made with the electrification of the disk opposite to that of the first and third.

Mean difference of the position of equilibrium, in scale-divisions	6·735
Spark-length	0·2845
Electro-dynamic force acting on the astatic pair—observed	0·00000327
" " " " calculated, M.	0·00000337
" " " " " W.	0·00000311

(2) Four experiments, the same.

Difference of the position	7·50
Spark-length	0·2955
Electro-dynamic force—observed	0·00000317
" " calculated, M.	0·00000349
" " " W.	0·00000322

(3) Five experiments, the same.

Difference of the position	7·60
Spark-length	0·2926
Electro-dynamic force—observed	0·00000339
" " calculated, M.	0·00000355
" " " W.	0·00000328

The accordance may be looked upon as satisfactory in the measurement of a force which amounts to only $\frac{1}{50000}$ of the force of the earth's magnetism, since in two of the series the observed values fall between those corresponding to the different measured values of Weber's constant.

As regards the signification of these experiments for the theory of electro-dynamics, they correspond to the hypotheses of the theory of W. Weber; but they can also be referred to Maxwell's, or to the potential-theory which takes account of the di-electric polarization of the insulators. The volume-elements of the stratum of air situated between the resting and the moved plates suffer continual displacements in the direction of a rotation round radially directed rotation-axes. The existing di-electric polarization of these elements will therefore in each material element continually change, while retaining in space the same direction normal to the surface of the electrified disks. The arising and disappearing components of this polarization would constitute the current which is indicated by the astatic pair of needles.—*Monatsbericht der kön. preuss. Akademie der Wissenschaften zu Berlin*, 1876, pp. 211–216; *Phil. Mag.*, Sept. 1876.

II. Geology and Mineralogy.

1. *Note on specimen of Metadiabase from Connecticut Lake, collected and sliced by G. W. Hawes.*—The fragments, apparently organic, in this slice agree with that figured by Mr. Hawes in the August number of the American Journal of Science, Plate v, fig. 5. They consist of a transparent brownish substance, traversed by parallel bars or ribs of greater transparency. In places the bars are interrupted abruptly, and crossed by similar bars nearly at right angles to the others. Between the longitudinal bars are irregular transverse and oblique lines; but these are not properly structural, and appear to be cracks, some of which are open and transparent, but the greater part closed and of a black color. From the irregular shape of the fragments, and the manner in which the ends project in shreds, it is to be inferred that the substance, if organic, was not hard or stony like a coral, but tough and soft, and in an advanced stage of decay. Fragments of the horny investment of Hydroids or Bryozoans might present such appearances, and in this case the planes where the bars are interrupted may represent the mouths of cells. Again, the chitinous crust of some Entomostracans, as for example, species of *Dithyrocaris*, shows bands not very dissimilar from those in the fragments, which, however, present no trace of the cellular structure usual in such crusts. Again, the Devonian plants of the genus *Dictyophyton* show a rectangular areolation which, though much coarser, reminds one of these specimens. Lastly, Gumbel has figured from the Laurentian of Bavaria certain films with rectangular meshes, much finer than those of Mr. Hawes' specimens, but not unlike them in appearance, and which he regards as organic. On the whole, though these objects are unlike any purely mineral substance with which I am acquainted, and are probably fragments of some organic body, I do not think it possible at present to indicate with any certainty their probable affinities.

Sept. 7, 1876. J. W. DAWSON.

2. *On Streams of Water beneath Glaciers.* — Mr. Charles Knight, in the Philosophical Magazine for June, states that, according to Professor Wm. Thomson's experiments, the freezing point of water is lowered 0°·23 F. for each additional atmospheric pressure; and that, hence, if a glacier have a thickness of 3,000 feet, the pressure would be about 80 atmospheres, and under this pressure the temperature at the base should not exceed 13° F. to retain the solid form. The statement needs a correction, since Professor Wm. Thomson's experiment made the lowering of the freezing point of water 0°·23 F. for *sixteen* atmospheres of pressure. This would give for 80 atmospheres, supposing the increase by arithmetical ratio, only 1°·15 F.

3. *Quinto Apendice al reino mineral de Chile i de las Republicas vecinas publicado en la segunda edicion de la Mineralojia de don* Ignacio Domeyko. 79 pp. 8vo. Santiago, 1876.—The fifth

Appendix by Domeyko to his Mineralogy of Chili follows the fourth after an interval of two years. It contains much valuable and interesting matter, including the description of the following new minerals:

Daubreite.—Amorphous. In structure earthy and compact, in parts fibrous. H.=2·5. G.=6·4–6·5. Color yellowish to grayish-white. Opaque. An analysis gave Bi_2O_3 89·60, Cl 7·50, H_2O 3·84(?), Fe_2O_3 0·72, which corresponds to the formula $(Bi_2O_3)_4$, Bi_2Cl_6. This formula places the mineral in the series with the two artificial compounds $(Bi_2O_3)_2$, Bi_2Cl_6, and $(Bi_2O_3)_6$, Bi_2Cl_3. It is easily soluble in hydrochloric acid, without residue. Locality, Constancia Mine, Cerro de Tazna, Bolivia.

Krönkite.—In irregular crystalline masses with coarse fibrous structure; probably triclinic. Cleavage distinct parallel to an edge of the prism. Color azure-blue, changing somewhat on exposure to the air. Luster vitreous; translucent. Composition $CuSO_4+Na_2SO_4+2H_2O$, which requires $CuSO_4$ 47·23, Na_2SO_4 42·09, H_2O 10·68=100. Perfectly soluble in water. Found in the copper mines near Calama, on the road from Cabija to Potosi, Bolivia.

Phillipite.—Forms small irregular masses and bands in the same argillacous ochre in which the copper pyrites occurs, by the decomposition of which it has been formed. Structure fibrous, sometimes compact; never prismatic like Krönkite. Color azure-blue. Luster vitreous; translucent. Soluble in water, but unaffected by exposure to the air. Composition $CuSO_4+\cancel{Fe}S_3O_{12}+$ n *aq.* Analysis gave SO_3 28·96, $\cancel{Fe}O_3$ 9·80, CuO 14·39, MgO 0·85, H_2O 43·72 $\cancel{Al}O_3$ *tr*=100·00. Found at the copper mines in the Cordilleras of Condes, Province of Santiago, Chili.

Huantajayite.—Isometric. Crystallizes in cubes like the chlorides of sodium and silver. H.=2. Transparent. Color white, not altered by exposure to the air. Fragile, easily reduced to a powder, not sectile like cerargyrite. Composition 20NaCl+AgCl; an analysis gave NaCl 89, AgCl 11=100. B.B. decrepitates and fuses easily, losing its transparency; with soda yields metallic silver. Found at the mine of San Simon, in the Cerro de Huanjayita.

The descriptions of the following new minerals in the Appendix are given by Sr. Raimondi.

Cuprocalcite.—Occurs in small masses, and in bands intimately mixed with a ferruginous carbonate of calcium. H.=3; G.=3·90. Color bright vermillion-red. The analysis gave Cu_2O 50·45, CaO 20·16, CO_2 24·00, H_2O 3·20, $\cancel{Fe}O_3$ 0·60, $\cancel{Al}O_3$ 0·20, MgO 0·97, SiO_2 0·30=99·88. This leads to the formula $(Cu_2O)_2CO_2+2CaCO_3+H_2O$, which requires Cu_2O 52·2, CaO 20·4, CO_2 24·1, H_2O 3·3=100. Soluble in hydrochloric acid with effervescence. The solution, formed with exclusion of the air, has a strong deoxydizing power, precipitating metallic gold from solutions of gold salts. Found at the mines of Canza, near the city of Ica, in Peru.

Werthemanite.—Occurs in powder, or in masses easily reduced to powder. Color white. Gives an argillaceous odor, and adheres

to the tongue. G.=2·80. Soluble only in sulphuric acid. An analysis gave SO_3 34·50, AlO_3 45·00, FeO_3 1·25, H_2O 19·25=100. This affords the formula AlSO_6+3H_2O; or like aluminite except in the smaller amount of water. Found near the city of Chachapoyas.

Malinowskite.—A variety of tetrahedrite. An analysis of the mineral from the district of Rocuay gave S 24·27, Sb 24·74, As 0·56, Pb 13·08, Cu 14·37, Ag 11·92, Fe 9·12, Zn 1·92=100. Other analyses of the same mineral from the mine of Carpa agree closely with this. It occurs massive, and has a gray color and metallic luster. E. S. D.

III. Botany.

1. *Flora of British India;* by J. D. Hooker, C.B., &c. Part IV. pp. 240. Date of issue not given.—This commences the second volume and contains the orders *Sabiaceæ*, *Anacardiaceæ*, and *Connarceæ*, by Dr. Hooker, and the *Leguminosæ* down to the genus *Derris* (two thirds of the 132 genera), by Mr. Baker. The model of the British Colonial Floras is followed. It is curious to find our *Clitoria Mariana* as an Indian species. A. G.

2. *Compositæ Indicæ descriptæ et secus Genera Benthamii ordinatæ*, a A. B. Clarke. Calcutta, Thacker, Spink & Co. 1876. pp. 347, xlv, 8vo, 1876.—This important side-contribution to the Indian flora is in Latin, but otherwise on nearly the plan of the Flora of British India, except that the generic characters are wholly given in the conspectus; and it is supplemented by copious tables of geographical distribution. The whole appears to be very well done, and, being published at the author's own expense, the cordial thanks of botanists are justly due. A. G.

3. *Proceedings of the American Association for the Advancement of Science, 24th meeting*, 1875. Botanical Articles.—These are few, occupying only 20 pages of the thick volume, and are not of high importance. The longest is that in which Mr. Meehan asks the question "*Are Insects [of] any material aid in fertilization*" of flowers? He answers the question in the negative, but not to our satisfaction. Some of the facts are open to question, or would take in other hands a different interpretation; and several of the illustrations of supposed self-fertilization are from flowers in which other observers, with opposite prepossessions, see exquisite adaptation to crossing. As we may not ourselves rightly appreciate Mr. Meehan's ingenious argumentation (our own observations all pointing to an opposite conclusion) we state that he claims to have proved:

"First, that the great bulk of colored-flowering plants are self-fertilizers.

"Secondly, that only to a limited extent do insects aid fertilization.*

* *Apropos* to Mr. Meehan's suggestion, that, although the alpine plants of the Colorado Rocky Mountains are mostly highly colored, insects are there so rare that they can be of no material aid to fertilization, and therefore these plants must self-fertilize, it may not be amiss to introduce testimony. An entomologist now

"Thirdly, that self-fertilizers are every way as healthy and vigorous, and immensely more productive than those dependent on insect aid.

"Fourthly, that where plants are so dependent, they are the worse fitted to engage in the struggle for life."

It is not easy to perceive how the last two very comprehensive propositions are or can be demonstrated.

The next article, on *Carnivorous Plants*, by Professor Beal, of Michigan, is short and sketchy, recapitulating some facts well-known in the science, though novel to a popular assemblage; and finally, referring to *Martynia* and the vast number of small insects which are caught by its sticky glands, he suggests that "it is a true insectivorous plant." That may well be; but the observations and experiments recorded were not carried to the point of proving it, although this might not have been very difficult.

Inequilateral Leaves, by the same author, is a brief article, detailing a good number of cases, and ending abruptly with the remark: "Why these leaves have unequal lobes I cannot see; and I have no theory to offer as a probable explanation."

The Venation of a few odd Leaves, also by Professor Beal, is a short note, in which the main point is a curious suggestion as to the morphology of the odd leaf of the Ginkgo tree.

Some Observations on the structure and habits of Utricularia vulgaris, by T. B. Comstock, is an abstract merely, describing the apparatus and apparent action of the bladders. "The value of this paper is slight, except as confirmatory, in a measure, of the discoveries of others, and as an illustration of the great ease of conducting similar observations, now much needed."

Lastly, *Periodicity in Vegetation*, by James Hyatt, of Dutchess Co., N. Y., is a longer article, noting how certain plants appear and disappear in different years, in certain places, *Silene antirrhina*, for instance, abounding in 1864, 1869, and 1874, "while not a single plant has shown itself, neither in 1875, nor in any other year than those specified since 1864;" from which it would appear that "the seeds lie dormant through the intermediate period." The article concludes with some noteworthy suggestions and plans for the convenient keeping of a useful botanical diary, especially for the recording of periodical phenomena. A. G.

at my side, who has passed four summers among these mountains and made frequent visits to the alpine regions, informs me that he has "always found insects of all orders quite abundant in the Rocky Mountains, and especially so wherever flowers occur in most variety, as in the immediate vicinity of the timber-line, 10,000 to 12,000 feet," etc. Also that "insects are much more abundant everywhere in the mountains than on the plains." He has "frequently noticed the congregation of butterflies, in considerable numbers, about the bleak and barren summits of rocky peaks far above the timber-line, whither they had probably been drifted by the wind. Bees and other Hymenoptera occur in considerable variety and abundance at the timber-line. In fact, one of the best places for collecting them is among the vast fields of flowers which there occur." Finally he remarks that "although, as a rule, insects, as well as other animals, are not so plentiful in all the Rocky Mountains as in many other parts of the country, yet, comparing the alpine regions with the plains, I have always found insects *very much* more abundant in the former than in the latter." A. G.

IV. Miscellaneous Scientific Intelligence.

1. *Prof. Huxley in New York.*—Three lectures on Evolution were delivered by Prof. Huxley to a very large and interested New York audience during the week which closed with his departure for England. He appealed chiefly to American facts in his lucid and well-conducted argument, and especially to those which had been gathered by Prof. Marsh, whose "enormous collections" in the Yale Peabody Museum he had examined a few weeks before. Respecting these collections he remarked: "I can emphatically say that so far as my knowledge extends, there is nothing in any way comparable to them for extent, or for the care with which the remains have been collected, or for their scientific importance in the series of fossils." The Cretaceous birds with teeth—Marsh's Odontornithes—and also the Dinosaurs (whose tracks he had seen in large numbers during an excursion under Prof. Marsh's escort to Greenfield, Massachusetts), were referred to at length in the second lecture, and the series of horses from the American Tertiary, in the third. Prof. Huxley closed as follows: "I did not, when I commenced this series of lectures, think it necessary to preface them with a prologue, such as might be expected from a stranger and a foreigner; for during my brief stay in your country I have found it very hard to believe that a stranger could be possessed of so many friends, and almost harder to imagine that the foreigner could express himself in your language in such a way as to be so readily intelligible to all appearance; for, so far as I can judge, that most intelligent and perhaps I may add most singularly active and enterprising body of the press, your press reporters, do not seem to have been deterred by my accent from giving the fullest account of everything that I happen to have said. [Great applause.] But the vessel in which I take my departure to-morrow morning is even now ready to slip her moorings; I awake from my delusion that I am other than a stranger and a foreigner. I am ready to go back to my place and country, but before doing so, let me, by way of epilogue, tender to you my most hearty thanks for the most kind and cordial reception which you have accorded to me; and let me thank you still more for that which is the greatest compliment which can be afforded to any person in my position—the continuous and undisturbed attention which you have continued to bestow upon the long argument I have had the honor to lay before you."

2. *The Eighth Annual Report of the Department of Marine and Fisheries of Canada*, containing the Report on the Meteorological and other Observatories, for the year 1875, has recently come to hand. The Canadian office, like that of our own army, contemplates both the study of climatological statistics, and the practical utilization of meterology especially in the prognostications of the weather. Its stations are classified as the central office, ordinary stations, chief stations, reporting telegraph stations, and

publishing telegraph stations. Thirteen Canadian stations send tri-daily reports to the central office at Toronto, whence they are telegraphed to Washington. At 36 stations storm warning signals, generally as suggested by telegraph from Washington, are displayed by hoisting the storm drum; 628 warnings were issued on 55 days in the course of 1875. For those stations from which reports have been published, about 80 per cent are reported verified.

The simultaneous observations at the Canadian stations are printed in full as a part of Professor Kingston's report, followed by the monthly, quarterly and annual averages of meteorological elements and other tabular matter.

In the report of the Director of the Magnetic Observatory at Toronto, it is stated that the Kew System of self-recording apparatus has been adopted there with considerable success. At the Montreal Observatory it is stated that the anemometer by Green is furnished with a self-recording attachment as made by Hahl & Co., of Washington. At Quebec, the noon-day time-gun has been fired daily by electricity, the machinery having worked with great satisfaction. The director of this observatory, Lieutenant E. D. Ashe, hopes that the observatory will soon take a prominent place in the study of physics. At St. Johns, New Brunswick, the noon-day time-ball, which is on the Custom House building, is dropped by the director in charge of that duty.

In singular contrast with the appreciation shown by the Canadian authorities of the importance of distributing accurate time to the shipping, is the utter neglect of the subject shown in the United States, where shipmasters are obliged to obtain accurate time, before leaving port, by application to some clock-maker, whereas the Naval Observatory at Washington might easily be authorized to furnish official standard time to the whole country.

C. A.

3. *British Association.*—Extended reports of the Glasgow meeting of the British Association are published in Nature, commencing with the number for September 7th (No. 378). The address of Sir William Thomson and Mr. Wallace, forming articles in this number, have been copied from that Journal. According to a note by Mr. Wallace, later published, *Kerguelen's Land*, p 368, second line from foot, should be *Tristam d'Acunha.*

4. *Diatoms in Wheat Straw.*—The article on this subject, by Professor P. V. Wilson, in the last volume of this Journal (p. 373), has, with good reason, encountered doubts and criticisms in other journals, both at home and abroad. After its publication, when it first met the eye of our botanical editor, he wrote us at once, pronouncing the alleged facts intrinsically absurd; and, in a subsequent number of the Journal, alluded to the mistake into which he supposed the writer of the article had honestly, but ignorantly fallen. An examination of the figures of the "Forms of Diatoms found in Col. Kunker's Straw"—reproduced with severe strictures, in the American Journal of Microscopy—has led him to write us further that his explanation can apply only to a few of the figures, and that the charitable construction must be withdrawn.—Eds.

APPENDIX.

ART. XLII.—*Notice of new Tertiary Mammals.* V; by Professor O. C. MARSH.

THE remains here described are from the Eocene of the Rocky Mountain region. They include a new genus of Equine mammals, allied to *Orohippus*, but an earlier and less specialized form, apparently in the direct ancestral line, and hence of much interest. All the specimens described are preserved in the Museum of Yale College.

***Eohippus validus*, gen. et sp. nov.**

This genus is very nearly related to *Orohippus*, but may be readily distinguished from it by the dentition, the last premolar above and below being similar to the next premolar in front, and not like the adjoining true molar, as in *Orohippus*. In other respects, the teeth in the two genera are very much alike, and the dental formula is the same for both. The feet, also in their main features, are very similar, there being in each genus four well developed toes in front and three behind, but *Eohippus* has a rudiment of the outer, or fifth, metatarsal, and may have had a similar remnant of the first digit in the fore foot. The radius and ulna, and the tibia and fibula were distinct, and entire, and in most other respects the skeleton resembled that of *Orohippus*.

The present species is based mainly upon a fragmentary skeleton, with the principal teeth well preserved. These remains indicate an animal about as large as a fox, but of rather more robust proportions. Some of the more important measurements are as follows:

Extent of three lower true molars	25·4 mm.
Antero-posterior diameter of last lower molar	11·2
Transverse diameter	5·4
Antero-posterior diameter of last lower premolar	7·
Transverse diameter	5·4
Antero-posterior diameter of first upper true molar	7·
Transverse diameter	9·5

The known remains of this species are from the *Coryphodon* beds, or lowest Eocene, of New Mexico. This horizon is below that in which *Orohippus* occurs.

Eohippus pernix, sp. nov.

A smaller species of the same genus is indicated by fragmentary remains of several individuals. Most of these fossils are in excellent preservation, and among them are some of the most characteristic portions of the skeleton. The distal end of the tibia is remarkably like that of the modern horse. The astragalus, also, is quite equine in type, but the anterior portion is more elongated. It has a small facet for the cuboid, as in the horse. The molar teeth are similar in pattern to those of *Orohippus*.

The following are some of the principal measurements:

Extent of three lower true molars	20· mm.
Antero-posterior diameter of first lower true molar	6·
Transverse diameter	5·
Depth of lower jaw below first true molar	11·
Antero-posterior diameter of distal end of tibia	13·
Transverse diameter	10·
Length of astragalus	15·5
Transverse diameter in front	10·

The remains here described are from the *Coryphodon* beds, or lowest Eocene, of Wyoming.

Parahyus vagus, gen. et sp. nov.

An interesting genus of suilline mammals is represented by a nearly perfect lower jaw and a few other remains in the Yale Museum. This jaw, which has most of the teeth well preserved, shows a near affinity to *Elotherium* Pomel, and to *Helohyus* Marsh, but it may easily be separated from those genera, as it has one less premolar. It differs from the former genus, moreover, in its last lower molar, which has a well developed posterior lobe. In other respects, the teeth are very similar to those of *Elotherium*. The present genus affords an interesting example of an extinct form outside of the ancestral line which terminated in existing suillines. A similar example is seen in *Anoplotherium*.

The specimens preserved pertained to an animal about the size of a modern wild boar, but the jaws were proportionately shorter and stouter. The canine was large, and the three premolars were all compressed, and each had two roots.

The dimensions of this specimen are as follows:

Extent of six molar teeth	138· mm.
Antero-posterior diameter of last lower molar	34·
Transverse diameter	17·
Antero-posterior diameter of first true molar	19·
Transverse diameter	13·
Depth of lower jaw below first true molar	46·

The only specimens of this species now known are from the lower Eocene of Wyoming.

Dromocyon vorax, gen. et sp. nov.

A new and remarkable carnivorous mammal about the size of a large wolf is represented in the Yale Museum by a nearly complete skeleton In the form of the skull, and general character of the jaws and teeth, the genus resembles *Hyænodon.* In the present specimen there were apparently but two lower incisors in each ramus. There are seven lower molar teeth, and the last lower molar is small. The top of the skull supported an enormous sagittal crest. The brain was small and convoluted. The lower jaws are long and slender, and the condyles low.

The femur has a small third trochanter and the astragalus a facet for the cuboid. There were but four toes in front, and four behind.

Some of the more important dimensions of this skeleton are as follows:

Length of skull from occipital condyles to front of premaxillaries	280· mm.
Distance from foramen magnum to top of sagittal crest	80·
Extent of lower molar series	131·
Extent of three true molars	70·
Antero-posterior diameter of last lower molar	15·
Transverse diameter	9·
Length of third metacarpal	78·
Length of third metatarsal	88·

The remains of this species at present known, are from the Eocene of Wyoming.

Dryptodon crassus, gen. et sp. nov.

The present genus belongs in the order *Tillodontia*, and is apparently most nearly allied to *Stylinodon.* It is based upon the nearly perfect lower jaws, with most of the teeth preserved, and some fragmentary remains of the skeleton of the same individual. These specimens indicate an animal nearly as large as a Tapir. The lower jaws are very short, and massive, especially in the anterior portion. In each ramus there were ten teeth, forming a continuous series. Three of these are clearly incisors, the two anterior being small and cylindrical, and the outer one of enormous size, compressed, faced in front with enamel, and growing from a persistent pulp. Next to this, was a small tooth which may have been a canine, and immediately behind this a series of six similar molars. The latter are cylindrical, and their sides nearly or quite covered with enamel. Three are apparently premolars, and the large incisor extends beneath them.

The principal measurements of this specimen are the following:

Extent of dental series	135· mm.
Extent of six lower molars	95·
Antero-posterior diameter of large incisor	37·
Transverse diameter	17·
Antero-posterior diameter of last premolar	16·
Transverse diameter	15·
Depth of lower jaw below canine	80·
Depth below first molar	60·
Depth below last lower molar	50·

The specimens above described are from the lower Eocene of New Mexico.

Yale College, New Haven, Oct. 23, 1876.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XLIII.—*Experiments on the nature of the force involved in Crookes' Radiometer;* by Prof. O. N. ROOD, of Columbia College.

IT is impossible for a physicist to regard the little instrument devised by Mr. Crookes with other than a feeling of unusual interest, based partly on the performance of the apparatus itself, and partly on possible applications which immediately suggest themselves. The explanation of these curious phenomena offered by Ronalds, and afterward more in detail by Stoney,* together with the confirmatory experiment of Schuster, led me to devise two new methods for still farther testing the theory thus advanced, and to make at the same time an examination of the phenomena when the suspended discs were under the ordinary atmospheric pressure.

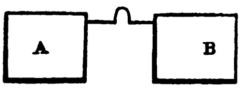
The explanation offered by Stoney is based on the mechanical theory of gases, and reaches the final result that a reaction takes place between the blackened sides of the movable vanes and the glass envelope, so that there is a tendency for them to recede from each other. I first arranged an experiment so that I could at will destroy the possibility of this reaction taking place, without interfering with the other necessary conditions.

Description of the apparatus.—Two discs of thin aluminium foil, A and B, fig. 1, the same in size, were prepared, and

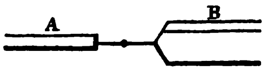
* On Crookes' Radiometer; G. Johnstone Stoney, Phil. Mag., March and April, 1876.

blackened, each on one side, with lampblack to which a minute portion of spirit varnish had been added. Each disc was folded so as to be double, the two leaves not being in contact. Disc B carried in front of it a plate of mica equal in size with itself, and distant from it about 5 mm. The system was arranged so as to be capable of suspension by a single fiber of silk, and was provided with a small directing magnet. Fig. 2 gives a view of the arrangement from above.

1.



2.



The discs thus arranged were enclosed in a clear glass flask, which was exhausted to a pressure of ·25 of a millimeter and sealed up.

The flask with its contents was then placed on a graduated circle and centered. The deviations of the disc were observed by a compound microscope of low power, which was capable of independent rotation about the axis of the circle. It was provided with an index with which tenths of degrees could readily be estimated, the circle itself being divided into half degrees. The small magnet connected with the discs was rendered nearly astatic by an external magnet: it consumed thirty-two seconds in making a single oscillation.

Experiments.—The light of a luminous gas-flame at a distance of twelve inches was allowed to fall on the blackened disc not provided with a plate of mica, its companion being protected by a triple screen of sheet brass from the action of the flame. Under these circumstances the exposed disc moved away from the light: after it had come to rest ten readings were made; below is the result obtained by two such experiments:

3°·06
3°·40
———
3°·23 mean deviation away from light.

Next, the vane provided with the mica shield was exposed, the other being screened. After a slight agitation it came to rest, and ten readings were made as before; the results of two experiments are given below:

0°·26 away from light.
0°·06 toward the light.
———
0°·10 mean.

It will be seen that the interposition of the mica plate attached to the vane actually did prevent any reaction from taking place between the disc and the walls of the flask, so that prac-

tically the disc remained immovable. In the next experiment the brass screen was entirely removed, and the light allowed to fall on both discs simultaneously, a plate of mica, identical in substance with that attached to the vane, being placed outside of the flask and opposite the unprotected vane, so that both vanes received the same amount of radiation, the only difference being that one of them was deprived of its direct communication with the walls of the flask. Under these circumstances the disc without the attached mica screen moved instantly away from the light, as was shown by two careful experiments:

$$\left.\begin{array}{l} 2^\circ{\cdot}42 \\ 2^\circ{\cdot}34 \end{array}\right\} \text{away from light.}$$

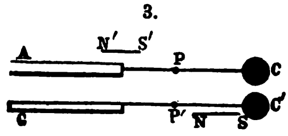
$$\overline{2^\circ{\cdot}38} \text{ mean.}$$

These results I regard as confirmatory of the theory advanced by Stoney, and as fatal to the idea that the motion is directly dependent on the impact of light or heat, for both discs received the same amount of heat and light.

According to the theory just referred to in these experiments repulsion took place between the blackened disc and the mica attached to it, but being firmly fastened together, no motion of either could result. Assuming this repulsion to exist I devised an apparatus for making it evident and for measuring its amount.

Description of Apparatus.—A disc of aluminium, folded double and blackened on one side, was provided with a small magnet, and suspended by a single fiber of silk in the interior of a glass flask. In front of this was similarly suspended a disc of glass such as is used for covering microscopic objects; it also was provided with a small magnet and both discs were properly counterpoised. These discs were each seventeen millimeters long, and fourteen millimeters high: the weight of each was 0·3 gram, and the minute magnets attached to them were of nearly equal strength. The distance of the points of suspension apart was five millimeters. Figure 3 furnishes a view of the system seen from above.

3.



A is the aluminium disc, G that of glass, P and P′ are the points of suspension, C and C′ the counterpoises, which being on different levels readily passed each other; and N S and N′ S′ are the controlling magnets. The exhaustion of the flask was carried to 0·24 of a millimeter.

Experiments.—It will be observed that the magnets were so arranged as to tend to cause the discs to touch each other, but

in ordinary daylight, or even in feeble daylight, the repulsion was so strong as to cause the discs to assume a parallel position, or even to diverge several degrees. They could not be brought into contact even by covering the flask with white writing paper, but paper thickly painted with lamp black always caused contact in a few minutes. When this apparatus was placed in a darkened room, and suddenly exposed to a luminous gas flame sixteen inches distant, the discs instantly diverged, right and left, with sensibly equal velocities, and after some slight oscillation came to rest. Below are given the final deviations in two trials; five readings being taken in each experiment.

Aluminium.	Glass.
12°·97	8°·36
12°·55	8°·43

Taking the mean of the two experiments, and calling the deviation of the aluminium 100, that of the glass is 65·7. The results just given are sufficiently concordant, and could have been obtained repeatedly without greater variation; still, owing to slight defects of workmanship in the apparatus, I do not lay any great stress on them, further than to prove that both discs are deflected, and that the deflection of the glass disc toward the light is somewhat less than that of the aluminium away from it. In another experiment with a similar apparatus, it was found that if the deviation of the aluminium was taken as 100, that of the glass was 74·8.

The result of this experiment, is, as it seems to me, absolutely fatal to any theory which assumes that the repulsion in a Crookes' radiometer is due to the direct impact of heat or light, and I think also it cannot well be explained by assuming the existence of ordinary convection currents.

Experiments under the full pressure of the atmosphere.—Being anxious to make some experiments under the ordinary atmospheric pressure, I arranged a blackened disc of aluminium foil, composed of two laminæ, counterpoised, provided with a small magnet, and suspended by a single fiber of silk in a glass flask. The time of oscillation of the system I could not determine, owing to friction against the air, but judge that it was between thirty and forty seconds. This apparatus was centered on the graduated circle, and the disc observed as before with a compound microscope. It was soon ascertained that the observer exercised, apparently, an attraction on the suspended disc, even when seated nearly in its prolongation; it followed and pointed toward the observer sitting at a distance of little less than a meter with considerable promptitude, being thus deflected from

its true position as much as 20°. The cause of this phenomenon I take to be, that the dark heat from the face of the observer warms mainly that part of the flask directly opposite him; this causes a feeble ascending current of air in that region, and this again a horizontal current toward the heated wall, the latter current acting on the disc precisely as the wind does on a weather-cock. The deflection from this cause was pretty constant, and did not prevent qualitative observations from being made, though in the more important cases I avoided it altogether by quickly taking the reading with the aid of a screen, and then retiring for some minutes to the other side of the room before taking a second reading.

Experiment with gas flame and a solution of alum.—The light of a luminous gas flame at a distance of a foot, after passing through a saturated solution of alum 41 mm. thick, was allowed to act on the blackened side of the disc, and forty readings were taken at intervals of about twenty seconds. A repulsion from the light was produced; below is given the deviation indicated by the mean of each successive set of ten readings.

0°·6 4°·01 3°·01 4°·1.

The alum solution was now removed, when the disc began to move rapidly toward the light, and after twenty readings, had reached a final deviation of 28°·7 toward the light. Here it remained stationary with small fluctuations. Being convinced that the deviation of 28°·7 was due solely to the heating of the glass by the naked gas-flame, causing thus a current to set toward it, and drawing the disc in that direction after the manner of a weather-cock, I moistened the side of the glass next to the gas flame with water at the temperature of the room, by the aid of a small camels' hair brush. For a second or two, no effect was produced; then a large repulsion ensued rather forcibly, the disc being driven away from the light, a deflection of as much as 180° being obtained, which tended of course to confirm the idea I entertained.

While making the observations just mentioned, I was seated near the apparatus: they were now repeated, at intervals of two minutes, the alum solution being employed, and the observer removing each time to a considerable distance from the apparatus. Below are the results of three experiments, consisting each of only two determinations of the zero point, and two of the deflection: 16°, 15°·4, 15°·8 away from light.

These and other equally constant results established beyond a doubt the fact that repulsion takes places when the radiations are such as not sensibly to heat the walls of the flask, and it is seen that with these conditions, the disc under the full atmospheric pressure *imitates the behavior of one suspended in a vacuum.*

I conceive the cause of these phenomena to be as follows: the radiations falling on the blackened disc heat it, and generate thus an ascending current of air, which sweeps upward along the surface of the disc, *gathering volume* as it travels from the lower to the upper edge, and tending thus to drive the disc away from the light. The cross section of the ascending current of heated air would then, roughly speaking, assume a shape like a V. To test this idea, I arranged the disc so that its upper edge should be bent away from the light, like an A, so as to give room to the ascending current of air; now, instead of hanging with its walls vertical, they were deflected as much as 15°. This deflection was so small as not materially to diminish the projection of the surface exposed to the light, but it was found practically to destroy the repulsion. Four experiments were made, each consisting of four readings of the zero point, and as many of the position of the disc after exposure, the observer removing each time to a distance from the apparatus; the results are given below.

Toward the light.	Away from light.
0°·2	2°·4, 0°·1, 1°·1.

This gives as the mean result a repulsion of 0°·8, and shows that the phenomenon differs essentially from that involved in a Crookes' radiometer.

With this same apparatus, the disc being still bent out of its vertical position, I now repeated the fundamental experiment of exposing the apparatus to the action of a naked gas flame under atmospheric pressure; the results of these trials are given below.

(1.) The disc remained stationary a moment, and then moved toward the light.

(2.) Same result.

(3.) Moved a few degrees away from the light, afterward 40° or 50° toward it.

(4.) 8° away from light, then a large number of degrees toward it.

(5.) Small deviation toward light, small deviation away from it, large deviation toward it.

(6.) Disc stationary, 5° away, 50° or 60° toward light.

(7.) 5° or 6° toward light, stationary, large deviation toward light.

The blackened disc was now arranged so as to hang vertically, and the experiment repeated, all the other conditions remaining unaltered.

(1.) Repelled 20°; then began to move slowly toward flame; on extinguishing the latter, a large sudden motion in same direction.

(2.) Repulsion of 40° or 50°; return to zero point; remained nearly stationary at zero point; sudden and large deflection toward flame, when it was extinguished.

(3.) Same as last.

(4.) Repulsion of about 5°, attraction 60°.

These experiments show that, as a general thing, the first effect is repulsion, the second attraction. They are, I think, sufficiently explained by assuming the existence of a vertical current, on the heated surface of the disc, and a horizontal current directed toward the heated side of the flask; these act antagonistically, and when the disc is vertical, often balance each other more or less perfectly for quite an interval. On extinguishing the flame, the vertical current is greatly weakened, while the horizontal one is not much affected, hence the violent deflection toward the heated side of the flask.

New York, June 27th, 1876.

ART. XLIV.—*Experiments on the Sympathetic Resonance of Tuning Forks;* by ROBERT SPICE.

IT is well known that a pair of forks having a vibration number of 256, (Kœnig's Ut^3 forks) show the phenomenon of sympathetic resonance at distances apart varying from three to six feet. Beyond six feet, special and delicate means have to be employed to exhibit their resonance.

It is also well known that a pair of forks having a vibration number of 512, (Ut^4 forks) exhibit the phenomenon with similar intensity at far greater distances. The accepted solution of this difference of deportment is, that as in the latter case double the number of impulses are delivered in a second, consequently double the energy is conveyed to the distant fork.

If this explanation be sufficient, the following result should follow: Forces radiating from a center obey the law of inverse squares; hence, if the amount of motion (or force?) received by an Ut^3 fork at a distance of six feet from its excited fellow be represented by n; then (assuming an Ut^4 fork to have double the energy of an Ut^3 fork,) clearly, the amount of motion received by an Ut^4 fork at a distance of twelve feet from its excited fellow, should be represented by $\frac{n}{2}$. But so far is this from being the case, that the intensity instead of being one-half (as calculated) is more than double. In fact, at twenty feet the

intensity of resonance of Ut^4 forks is undoubtedly greater than the intensity of Ut^3 forks at six feet.

A pair of forks were cast in a kind of bell-metal, and tuned to Ut^3. On Kœnig's boxes the resonance was quite obvious at twenty feet, and at forty feet the responding fork drove a cork ball 8^{mm} diameter a distance of 10^{mm}! This result was greater than that obtained with the steel Ut^4 forks of Kœnig. In view of these facts, it seemed to me that a different explanation was required to clear up the difficulty: and, after a careful experimental examination of the question, I offer the following hypothesis:

The intensity of sympathetic resonance of forks on their cases increases with the angular deviation or motion of the prongs.

The question of number of vibrations per second has its proper value, but this value is small compared with the element above stated.

I proceed to explain this hypothesis. Suppose that we wish to set a pendulum in motion, but are required to fulfill the two following conditions: First. We are obliged to hold the cord of the pendulum (point of suspension) in our hand, and this hand is also to be the motive power, to start and keep the pendulum in motion. Second. We are only to be allowed a lateral movement of the hand of one inch each way, making in all two inches.

Now the amount of motion or amplitude of a pendulum is estimated by the angle the cord or rod makes with the vertical; and clearly, if the point of suspension moves laterally, it thereby creates an angle. If, further, the point of suspension has a reciprocal motion in accord with the possible time of the pendulum, then, by the principle of the summation of impulses, the motion of the entire pendulum will be gradually augmented up to a limit determined by well-known mechanical theorems. But if amplitude is expressed by angular magnitude, then, if the initial angle be increased, the total motion must be acquired in less time and be greater. From which it follows that, retaining the conditions above stated, if we operated on a pendulum ten inches long, we should set it in its maximum motion in less time and with less expenditure of force than if we operated on a pendulum fifty inches long. Experience confirms this.

A fork vibrates after the manner of a pendulum, and may be looked upon as an inverted pendulum; but whereas, the *length* of a pendulum determines its vibrating period, the *length* and *thickness* together determine the period of a fork. Again: the period of a fork varies *directly* as the *thickness*, but inversely as the *square of the length;* hence a small alteration of length will make a large difference in its period; or, conversely, a

large alteration of period does not imply a large difference in length.

From measurements made with an electro-chemical registering apparatus, which I designed for this and similar investigations, I find that when a fork of the usual dimensions (between Ut^3 and Ut^4) is in vibration, its stem or handle alternately rises and falls in accord with the period of the fork, through a distance of about $\frac{1}{70}$ inch. When a fork on its case is influenced by a distant fork, the case gives the stem this up and down motion, which is conveyed to the prongs and sets them in vibration after the manner of the hand starting a pendulum as specified above.

This motion of $\frac{1}{70}$ inch may be looked upon as a constant, and corresponds to the two-inch motion of the hand in the illustration. If we decrease the length of the fork without altering the constant, we thereby allow of a greater initial angle; the result of which we have already noted—it is the same as shortening the pendulum cord. This much understood, we are in a position to explain the deportment of the bell-metal forks cited. The velocity of sound in bell-metal is much less than in steel, hence, retaining similar thicknesses in both cases, an Ut^3 fork in bell-metal would be shorter than an Ut^3 fork in steel; the ratio of the length of the steel to that of the bell-metal ranging as 90 : 75. Therefore, though we retain the vibration-number, we gain advantage from the shortness of the fork, and hence from the increase of angular motion of the prongs.

It was suggested to me that possibly bell-metal had the property of accepting motion more readily than steel. To test this point I made a pair of Ut^3 steel forks, shorter than Kœnig's, and of course thinner, in order to retain the vibration-number. These forks behaved just like the bell-metal forks. Further, I made a pair of Ut^4 forks as long as Kœnig's Ut^3 forks, and of course thicker. These behaved like Kœnig's Ut^3 forks. Finally, taking a Kœnig Ut^3 fork on its case, and one of the short Ut^3 forks also on its case; on placing them twenty feet apart, it was found that, on exciting Kœnig's fork, my short fork responded well, whereas on exciting the short fork Kœnig's did not respond at all.

230 Bridge st., Brooklyn, July, 1876.

ART. XLV.—*Types of Orographic Structure;* by Major J. W. POWELL.

[The following pages on "Types of Orographic Structure," are cited from Major Powell's Report on the "Geology of the Uinta Mountains." They are preceded in the volume by a brief topographical account of the region between the Sierra Nevada and the Front Range of the Rocky Mountains, and having for its northern boundary, as at present understood, the North Platte and its proper upper continuation, the Sweetwater River. This area is divided into three provinces, namely—passing from east to west,—the Park Province, the Plateau Province and the Basin Province. The first is described as including the great parks of Southern Wyoming, Colorado and Northern New Mexico, and comprises many ranges of mountains which are "characterized by a great development of metamorphic crystalline schists, mostly Archæan in age, with patches and structural basins of marine and lacustrine sediments of later time, and a complicated series of volcanic formations.

The Plateau Province is that directly drained by the Colorado and its tributaries, through which the streams generally run, not in wide valleys, but in cañons; the vast area is strictly a plateau region embracing many table-shaped elevations bounded by cañon and cliff escarpments, and differing in its succession of sedimentary strata from others in North America, and also in its displacements or uplifts; moreover, Cenozoic and Mesozoic rocks prevail, though some of the important plateaus are of Carboniferous beds, and in places the subjacent rocks even down to the Archæan are exposed to view in consequence of erosion.

The Basin Range system includes the Great Salt Lake region, and other valleys and ridges extending through Western Utah, Nevada, Southeastern California and perhaps across the Colorado in Western Arizona; and embraces Paleozoic beds as well as metamorphic schists, along with eruptive beds, some of which are the principal component parts of the ranges.]

IT seems convenient to give a general account of the types of orographic structure in the Colorado region before characterizing each province by its special type.

In this discussion I wish to use certain terms with a restricted or relative meaning; i. e., in treating of anticlinal and synclinal flexures I shall speak of those portions of the sedimentary beds which are adjacent to the anticlinal axes as having been upheaved, and those portions near their synclinal axes as having subsided. Again, in blocks which are bounded by faults and tilted, I shall speak of such portions as are at a higher level as having been uplifted, and portions occupying a lower level as thrown. In such cases I do not wish to commit myself to any

theory of upheaval or collapse in the change of the relation of the several parts of these beds to the center of the earth.

In treating of the structure of the mountains under consideration it is necessary to distinguish two great classes, viz: those composed of sedimentary strata, altered or unaltered, and those composed of extravasated material.

Mountains composed of Sedimentary Strata.

I. *Appalachian Structure.*

The structure of the Appalachian Mountains, with closely appressed folds and axial planes tipped back from the sea, the modifications of these folds by faults, and the primary and concomitant forms of the mountains, have been clearly explained by the Messrs. Rogers and later writers, and have formed the basis of many discussions concerning geological dynamics. This Appalachian structure needs no further mention here, as it is a type of structure which so far has not been found in the region described above, and should it be found hereafter it will simply be an exceptional type to those known to prevail.

II. *Simple Anticlinal Structure.*

Mountains or short ranges carved from simple anticlinals are sometimes found, though this type of structure is not a prevailing one. Usually in such a case the great mountain mass lies in the central zone of the uplift. The fold is, of course, always found truncated by erosion, and the mountains represent but the difference between the amount of upheaval and the amount of such erosion. When not complicated by other types of structure the strata dip on all sides from the center of upheaval, gently or more abruptly, but the sides of the folds are never closely appressed. Such mountains in primary form are gently rounded in general outline, modified by the erosion of the streams running down their sides. Sometimes such mountains are severed by rivers running longitudinally, transversely or obliquely through them; the rivers themselves having their sources in regions far away and passing through the mountains in their courses to the sea. In Northeastern Colorado a short distance above the junction of the Snake River with the Yampa, stands Junction Mountain, which serves as a fine illustration of this type of structure. The mountain is divided into two unequal parts by a cañon, through which the Yampa River runs. The axis of the mountain has a north and south direction.

Figure 1 is a section through this mountain, in a north and south direction, along the axis of upheaval. Figure 2 is a section through it in a transverse direction.

Concomitant Forms.

1. *Monoclinal Ridges on the Flanks.*—Under conditions which are so well known as to need no further explanation here, monoclinal ridges or hogbacks are formed on the flanks of such up-

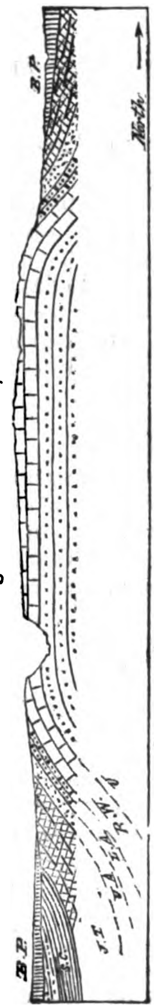


Fig. 1.—Section through Junction Mountain, north and south.

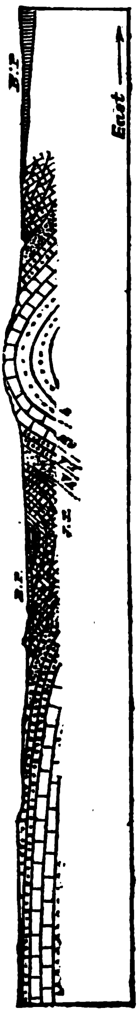


Fig. 2.—Section through Junction Mountain, east and west.

B. P., Brown's Park; S. C., Sulphur Creek; J. T., Jura Trias; U. A., Upper Aubrey; L. A., Lower Aubrey; R. W., Red Wall; U., Uinta.

heavals, and sometimes such monoclinal ridges are of such magnitude as to be dignified with the name of mountains. Where two or more series of indurated, inclined beds are separated by extensive series of softer material, two or more monoclinal ridges may be formed.

2. *Monoclinal Ridges only.*—Sometimes we find that an anticlinal upheaval has been eroded in *intaglio*, so that there is no great central mountain mass, but the axis of upheaval is the site of a valley or low plain, but the monoclinal ridges on the flanks remain.

3. *Inclined Plateaus.*—Where the anticlinal upheaval has a great amplitude, as compared with the vertical uplift, the beds incline but slightly. Under such conditions inclined plateaus or mesas are found instead of monoclinal ridges, usually having steep escarpments facing the axis of the flexure.

III. *Uinta Structure.*

In the Uinta Mountains we have a great range carved from an anticlinal upheaval, the axis of which has an easterly and westerly trend, and is more than one hundred and fifty miles in length. It terminates abruptly against the Wasatch Mountains on the west and is cut off by the short, abrupt anticlinal of Junction Mountain on the east, the latter having its axis in a north and south direction. There are several important facts observed in the study of this great flexure. Its axis has been lifted above the level of the sea about thirty thousand feet, and above the level of the adjacent country about twenty-five thousand feet. From flank to flank the flexure is about fifty miles, but varies much in width. We find on either flank, many miles from the axis, a line of maximum flexure, which line presents a subparallelism with the meandering axis. These lines have the effect of two monoclinal flexures in opposite directions, separated by the broad table, diversified by elevated valleys and peaks of which the great mass of the Uinta Mountains is composed. But the portion between these monoclinal flexures or lines of greatest flexure is itself gently flexed. In many places that which I have called the line of greatest flexure is indeed a fault, in one place on the north side of the Uinta Mountains having a throw of twenty thousand feet. On the south side the line of greatest flexure is very irregular, being complicated in some places by faults having uplifts opposed to the downthrow of the flexure. On either side the great displacement is partly by faulting, partly by flexing, and either flank is a zone of diverse displacement where the strata are faulted, flexed, twisted and contorted in many ways.

The character of these displacements in the Uinta Mountains is illustrated in Plates, 1, 2 and 3 of the Atlas, and in a subsequent chapter the subject will be more fully discussed.

The simplest topographic forms, produced by such displacements under conditions of erosion in general outline, are plateaus with gently rounded summits and abrupt shoulders on the flanks; but such general outline is often modified by the

corrasion due to antecedent or superimposed drainage; that is, by the corrasion of streams that head in remote regions and pass through these uplifts either longitudinally, transversely or obliquely, as in the case of Simple Anticlinals.*

There are other modifications which sometimes greatly obscure the general topographic outline due to consequent drainage, i. e., the local drainage which is due to the upheaval itself and which produces interesting

Concomitant Forms.

1. *Subsidiary Plateaus.*—Sometimes the streams which head near the axis of such an upheaval, as they meander to the flanks, excavate valleys and divide the great block, which is a plateau in general outline, into minor plateaus which are separated by intervening but elevated valleys. This is especially the case where the streams in their upper courses follow for some distance the strike of the beds before turning to cross the more or less abrupt lines of maximum flexure. Sometimes these streams run in deep gorges; in such cases the plateaus are bounded by cañons.

2. *Projecting Ridges.*—When these consequent streams starting near the axis of upheaval take a somewhat direct course across the strike, the general plateau is cut into a series of sharp, abrupt ridges having a trend at right angles to the strike or general axis of upheaval. Thus the points of the ridges face the plain below and are separated by deep gulches and cañons, and the observer on the plain below sees before him what appears to be a line of peaks separated by intervening gulches and valleys, and is apt to misunderstand the topographic character of the great mass which is before him.

3. *Axial Peaks.*—At some stages in the progress of erosion the channels of consequent drainage inosculate, and about their heads gorges are formed, with towering amphitheaters. In such cases an irregular line of crags and peaks will be found along the axis of upheaval. These I call axial peaks.

4. *Flanking Peaks.*—Sometimes we find a very hard bed or group of beds underlaid by more friable strata on a flank of the upheaval, which harder beds have been carried away by erosion from those portions of the upheaved mass nearer the axis. In such cases each projecting ridge is crowned with a true peak. I call these flanking peaks.

5. *Interrupted Monoclinal Ridges.*—On the flanks of these upheavals, but farther from the axis than the flanking peaks, monoclinal ridges are often found sometimes broken by gaps

* For an explanation of what is meant by antecedent and superimposed drainage, the reader is referred to the Report on the Exploration of the Colorado River and its Tributaries, page 160, *et seq.*

which are the channels of intermittent or permanent streams, and these ridges are very irregular and often interrupted. Where the downthrow is by simple flexure, a complete series is formed. Where it is partly by flexing and partly by faulting, some of the monoclinal ridges disappear. Where the faulting is on the side of the zone of maximum flexure nearest to the axis, the ridges of the upper beds appear; but where the faulting is on the side of the zone of maximum flexure farthest from the axis, the ridges of the lower beds appear; and where the displacement is chiefly or entirely by faulting, there are no monoclinal ridges.

IV.—*Kaibab Structure.*

In the region under discussion we often find the sedimentary beds broken into blocks by faults or their homologues, monoclinal flexures, and these blocks have been gently tilted in broad masses. I have discussed this subject somewhat at length in my Report on the Exploration of the Colorado River of the West and its Tributaries, published in 1875; and in fig. 3 I reproduce a section and bird's eye view of the plateaus north of the Grand Cañon, which was used in that volume. An examination of this will fully reveal the characteristics of what I have called the Kaibab structure. The grand topographic features which result from this structure are plateaus with broken edges where they are bounded by faults, flexed edges where they are bounded by monoclinal flexures, and with escarpments where they are bounded by cañons or lines of cliffs.

Concomitant Forms.

1. *Cliffs of Displacement.*—When a plateau is bounded on one side by a fault, the edge of the plateau is an escarpment often so abrupt as to present a more or less irregular line of cliffs.

2. *Slopes of Displacement.*—When the displacement is a flexure rather than a fold, the edge of the plateau is a broken slope. I have discussed these cliffs and slopes of displacement somewhat at length in the volume already quoted several times, page 182 *et seq.*

3. *Monoclinal Ridges on the Flanks.*—On the flanks of these monoclinal flexures, under proper conditions which have already been described, monoclinal ridges are formed.

4. *Monoclinal Ridges with Plateau carried away.*—As in simple anticlinal upheavals the central mass may be entirely carried away leaving but monoclinal ridges, in like manner in the Kaibab structure the principal plateau mass may be carried away leaving only the monoclinal ridges. This I have also discussed in the volume already quoted.

5. *Projecting Ridges.*—It is seldom, perhaps never, the case that the strata of one of these plateaus are left by the general

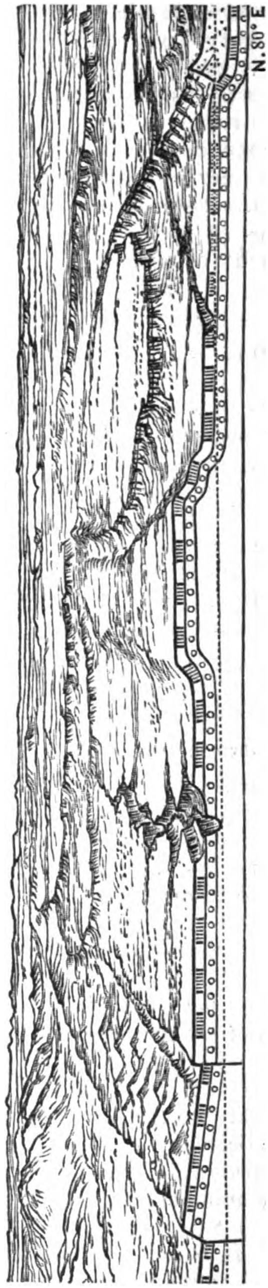


Fig. 3.—Section from west to east across the plateaus north of the Grand Cañon, with bird's-eye view of terraces and plateaus above. Horizontal scale, 16 miles to the inch; vertical scale, 4 miles to the inch.

displacement in a horizontal position; but every block is tilted more or less, and often a valley appears at the foot of the slope, and the streams which head on the opposite brink of the plateau have excavated valleys, leaving intervening ridges which project into the valley, having an effect somewhat like that described as one of the concomitant forms of the Uinta structure.

6. *Cliffs of Erosion.*—An inclined plateau may be bounded on the upheaved side by an escarpment of erosion, and such an escarpment is gradually carried back by an undermining process from the line of greatest upheaval. The drainage of such a plateau is usually from the brink of this escarpment toward the valley on the opposite side; yet a minor drainage is found which carves out deep gulches, and the cliffs of erosion have deep reëntrant and sharp salient angles.

7. *Buttes.*—Sometimes the gulches which form the deep, reëntrant angles of a line of cliffs have lateral gulches, which by continued erosion coalesce, and the salient angles are gradually cut off from the escarpment, which is ever retreating. In this manner buttes are formed as outliers of cliffs.

8. *Cameo Mountains.*—Wherever considerable areas of horizontal or nearly horizontal strata are found sufficiently elevated above the base level of erosion, and such areas are drained by two or more subparallel water-courses, the lateral drainage of these water-courses will gradually inosculate in their upper ramifications, and, carving out deep channels, will leave behind mountains of horizontal strata. Such mountains are often of great beauty. This is especially the case where the beds are of different texture and color, when the mountains will be terraced and buttressed in beautiful regularity, and banded with the colors which are characteristic of the several beds of which they are composed.

A few miles north of the Uinta Mountains, on the west side of the Green River, a group of such mountains is found, to which I have given the name Cameo Mountains, and I call this the Cameo structure.

V. *Basin Range Structure.*

When the blocks into which a district of country has been broken by faults are greatly tilted so that the strata dip at high angles, the uplifted edges of such blocks often form long mountain ridges. Such ridges have the general appearance of the monoclinal ridges already described as concomitants of other types of structure: but in this case the ridges constitute the chief mountain masses themselves, and form another general structural type. The monoclinal ridges are due to the erosion of upheaved strata; these ridges are due to displacement; they may also be eroded, but in so far as erosion has progressed the

ridge-like structure is obscured. Many of the ridge-like mountains of the Basin Province have this structure. Such a ridge is composed of monoclinal strata, the one side presenting a bold escarped front, the other a more gently sloped back conforming

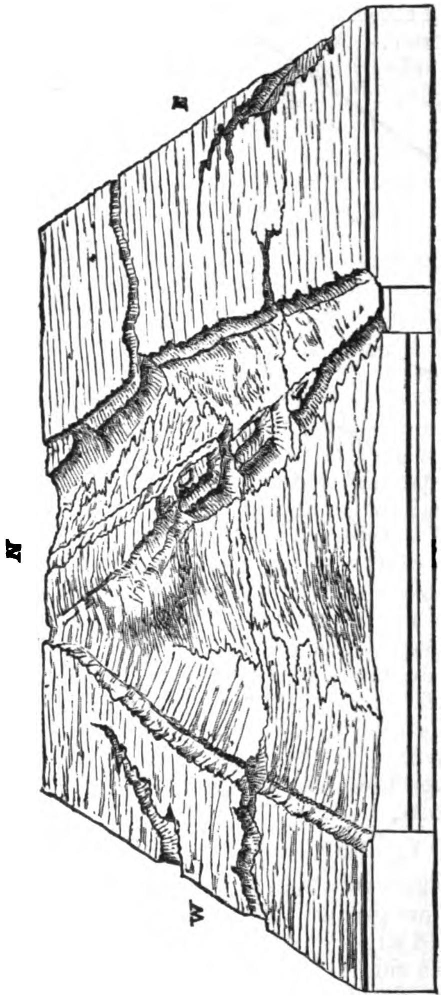


Fig. 4.—Bird's-eye view of a portion of the Musinia Zone of Diverse Displacement. The area represented is six miles square. The base line shows the sea-level. The tract is drained by Salina Creek, which unites its branches in the center and flows through the cañon on the left.

to a greater or less degree with the dip. Sometimes the ridges themselves are faulted longitudinally, transversely or obliquely, and the faults may be slight or of great magnitude; but the more common structure is a simple ridge with slight transverse or oblique faults.

CONCOMITANT FORMS.

1. *Monoclinal Ridges on the Back.*—On the backs of these Basin ranges monoclinal ridges have been observed.

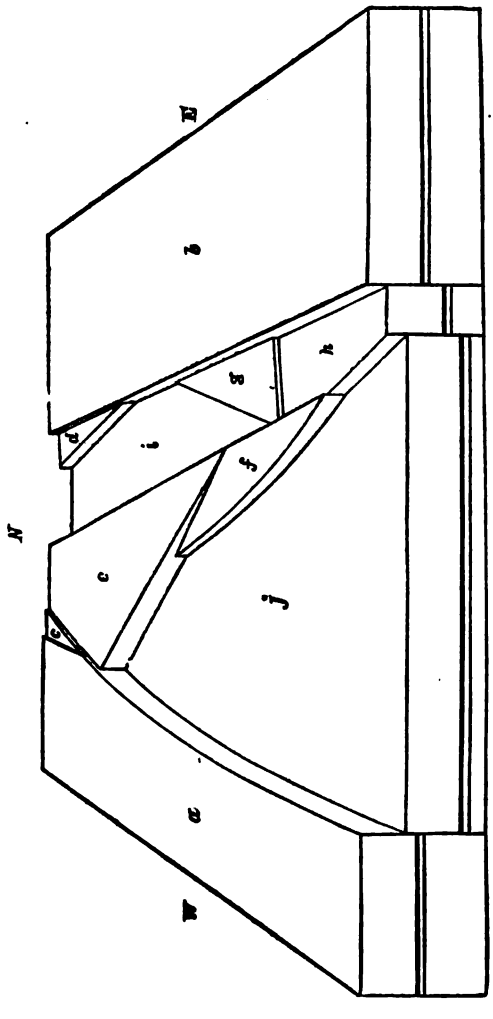


FIG. 5.—Deduced from Fig. 4. A restoration of the displaced rocks as they would appear had there been displacement but no degradation.

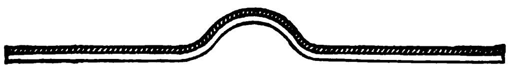
VI.—*Zones of Diverse Displacement.*

In this region many zones or irregular areas of country are found to be divided into small blocks by faults and flexures running in diverse directions, and these may be horizontal or be tipped at high or low angles, or even be overturned. The total effect of this diverse displacement may be to uplift the

area above, or depress it below, the adjacent country, or not to change its relative altitude. These features are exhibited on a small scale within a limited area, usually so elongated as to be termed a zone.

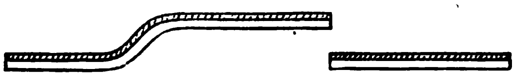
During the past season Mr. G. K. Gilbert has studied an area where this diverse displacement is by faulting, and the faults are of no great magnitude, and the blocks into which the area has been severed are either not tilted or but slightly so. This presents the simplest illustration of this type that has yet been discovered. It is simply the Kaibab structure on a very small scale. Fig. 4 is a bird's eye view of the blocks mentioned. In

FIG. 6.—Types of Displacement.

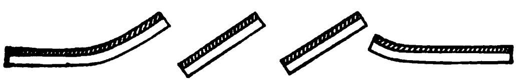


A.—Simple Anticlinal displacement.

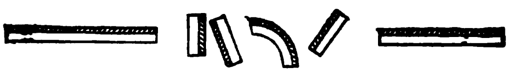
B.—Uinta displacement.



C.—Kaibab displacement.



D.—Basin Range displacement.



E.—Zone of Diverse displacement.

the section, in the foreground, the heavy line represents the summit of the highest Cretaceous group. Fig. 5 is a diagram of the same region showing the blocks into which it is severed, and the same restored to the condition they would have, had there been no denudation.

On the south side of the Uinta Mountains, and east of the Green River, another comparatively simple area has been studied by myself. This zone of diverse displacement is on the flank of the great Uinta upheaval. These displacements are chiefly by flexures rather than by faults, and the blocks are more tilted and contorted than in the last.

In Atlas, plate No. 4, we have a stereogram representing these displacements, and in a subsequent chapter the subject is more fully discussed.

Many other areas far more complex than these have been discovered, where a zone has been broken into blocks, and these blocks tipped and contorted in diverse ways and directions, like the blocks of ice crowded in an eddy of a northern river at the time of its spring flood. The topographic features found in such areas are zones of irregular hills.

Figure 6 is a diagram illustrating the general types of displacement heretofore discussed. A represents a Simple Anticlinal displacement; B, a Uinta displacement; C, a Kaibab displacement; D, a Basin Range displacement; and E, a Zone of Diverse displacement.

MOUNTAINS COMPOSED IN WHOLE OR IN PART OF EXTRAVASATED MATERIAL.

We are not able in the present state of our knowledge to draw legitimate conclusions concerning the relation of the eruptive rocks, so widely distributed through all three of these geological provinces, but the following types of structure have been observed.

VII.—*Table Mountain Structure.*

We often find beds of sedimentary strata preserved from erosion by a capping of lava. Such are usually called table mountains; the underlying strata may be horizontal or inclined. Earlier stages of this structure are seen in *mesas* or low tables, and sometimes in valleys or gulches which have been filled with extravasated material, and erosion has proceeded to a limited extent on either side of these harder masses, carrying away the softer sedimentary material, and leaving the harder volcanic rocks in the midst of the valley; and this may have an elevation less or greater than that of the adjacent country beyond the rim of the valley.

A fine example of a table mountain is found in Pilot Butte, in Wyoming Territory.

VIII.—*Uinkaret Structure.*

Simple sheets of lava may be poured into a valley or on a plain, and serve as a protection to the sedimentary beds which are immediately underlying them, and as the erosion of the adjacent country not thus protected progresses, new vents may be formed along the edges of such sheets and at a lower level. Still erosion progresses, and still new floods of lava are poured out, and still at lower levels, until a mountain is left behind with its central mass composed of sedimentary material, but covered on the summit and flanks with irregular and overlap-

ping patches of lava. Thus lava bed is imbricated on lava bed, but unlike the tiles of a roof, the upper edge of the lower sheet is placed on the lower edge of the upper. This structure is well represented in the Uinkaret Mountains in Northern Arizona, and has been more fully discussed by me elsewhere. (*Vide* The Exploration of the Colorado River, &c., page 199 *et seq.*)

IX.—*Tu-Shar Structure.*

When a plain or valley which receives extravasated material from below remains at a base level of erosion during the period of successive eruptions, flood of lava is piled on flood of lava until a vast mass of material is accumulated from which the rains and streams carve mountains. The several beds of which such a mountain mass is composed are exceedingly irregular, from three causes: first, each bed as poured out was an irregular mass, due to its degree of fluidity and the character of the ground on which it was poured; second, each bed was more or less modified by erosion, which occurred after it was poured out, and before it was covered by a subsequent flood; and, third, the general mass has been eroded to a greater or less extent in producing the present forms.

The volcanic activity being in a region where movements of displacement are in progress, it is often the case that the structure of this class of mountains is greatly modified by such displacements. Mountains composed of such irregular beds of lava are of frequent occurrence in the region under discussion. A fine example is seen in the vicinity of the town of Beaver, Utah Territory, in what are known as the Tu-shar Mountains.

X.—*Volcanic Structure.*

When many eruptions come successively from the same vent, and each is a comparatively small amount, cones are built. Cones of such simple structure are of frequent occurrence in the region under discussion. Great complex cones such as are found in other parts of the world do not occur, but a few double and one triple cone have been observed. The great majority of the cones observed are built of cinders on broad sheets of lava, and are in fact concomitant forms of lava mesas. Such cones are comparatively ephemeral, as the scoria and ashes of which they are composed yield readily to atmospheric degradation. Where such a cone exists, still having a well defined crater, its condition testifies to the lateness of its origin, and all the facts relating to the sheet of lava on which it rests fully corroborate the conclusion. From such evidence we are able to infer the recency of much of the volcanic activity in the three provinces. If the human history of America could be carried back to as early a date as it has been in Asia, it cannot be doubted that the earlier chapters of that history would be replete with the accounts of volcanic fires.

XI.—*Henry Mountain Structure.*

Sometimes we find the sedimentary strata displaced by a quaquaversal upheaval and the same fractured, and through these fractures floods of lava have poured, and these may lie in patches about the flanks of the mountains, or stand in dikes where the walls of the crevice have been swept away by denudation. In the Henry Mountains we have a fine illustration of this type of structure. These mountains have been studied by Mr. Gilbert during the past season, and in his preliminary report he says: "The eruptions of the Henry Mountains are of a character entirely novel to me, and they were studied with an interest stimulated by surprise. A description of a single one, though it will not stand for all, will serve to illustrate the type.

Mount Ellsworth is round, and its base is six or eight miles broad. The strata of the plain about it are horizontal on every side. Near the mountain the level strata become slightly inclined, rising from all sides toward the mountain. At its base the dip steadily increases until on the steep flanks it reaches a maximum of forty-five degrees. Then it begins to diminish, and the strata arch over the crest in a complete dome. But the top of the dome has cracked open, and tapering fissures have run out to the flanks, and they have been filled with molten rock, which has congealed and formed dikes. Moreover, the curving strata of sandstone and shale have in places cleaved apart and admitted sheets of lava between them. So the mountain is a dome or bubble of sedimentary rocks with an eruptive core, with a system of radial dikes, and with a system of dikes interleaved with the strata. It is a mountain of uplifted strata, distended and permeated by eruptive rock."

* * * * * *

In the foregoing characterization of certain types of structure found in these regions, I have not attempted to adopt a system of exact classification, which should be both inclusive and exclusive as the types do not admit of such classification. No "hard and fast lines" can be drawn. I have simply attempted to indicate the important types with their primary and concomitant forms.

It is manifest that the structure of a sedimentary mountain will depend primarily upon two elements—the type of the displacement and the character and extent of erosion. The erosion may be antecedent or superimposed, or it may be consequent, or these methods may be combined, and the erosion may be modified by dip, texture, and other characteristics of the beds producing concomitant forms.

For convenience, I subjoin the following synopsis of the types of mountain structure recognized in the foregoing discussion.

I. MOUNTAINS COMPOSED OF SEDIMENTARY STRATA, ALTERED OR UNALTERED.

I.—*Appalachian Structure.*

(Not found in the three provinces.)

II.—*Simple Anticlinal Structure.*

Primary topographic form: Plateau with rounded vertical outline.

Concomitant forms: 1. Monoclinal Ridges on the Flanks. 2. Monoclinal Ridges only. 3. Inclined Plateaus.

III.—*Uinta Structure.*

Primary topographic form: Plateau with rounded summit and abrupt shoulders on the flank.

Concomitant forms: 1. Subsidiary Plateaus. 2. Projecting Ridges. 3. Axial Peaks. 4. Flanking Peaks. 5. Interrupted Monoclinal Ridges.

IV.—*Kaibab Structure.*

Primary topographic form: Plateau with angular outlines.

Concomitant forms: 1. Cliffs of Displacement. 2. Slopes of Displacement. 3. Interrupted Monoclinal Ridges on the Flanks. 4. Monoclinal Ridges with Plateau carried away. 5. Projecting Ridges. 6. Cliffs of Erosion. 7. Buttes. 8. Cameo Mountains.

V.—*Basin Range Structure.*

Primary topographic form: Monoclinal ridges of displacement.

Concomitant forms: 1. Monoclinal ridges on the back.

VI.—*Zones of Diverse Displacement.*

Topographic form: Irregular hills.

II. MOUNTAINS COMPOSED IN WHOLE OR IN PART OF EXTRAVASATED MATERIAL.

VII.—*Table Mountain Structure.*
VIII.—*Uinkaret Structure.*
IX.—*Tu-Shar Structure.*
X.—*Volcanic Structure.*
XI.—*Henry Mountain Structure.*

ART. XLVI.—*On the Ethers of Uric Acid. Contributions from the Chemical Laboratory of Harvard College*; by H. B. HILL,* Assistant Professor of Chemistry.

ALTHOUGH the constitution of many of the derivatives of uric acid may be said to be fairly established, the structure of uric acid itself is still a matter of conjecture. The formulæ given by Bäyer,† Kolbe,‡ Strecker,§ Erlenmeyer,‖ Mulder,¶ Hüfner,** Gibbs,†† Medicus,‡‡ Drechsel,§§ and Mallet;‖‖ dif-

* In great part from the yet unpublished Proceedings of the Am. Acad., p. 26.
† Ann. Chem. u. Pharm., cxxvii, 235.
‡ Journ. für prakt. Chem. II, i, 134. Berichte Deutsch. Chem. Gesellsch., iii, 183.
§ Zeitschr. für Chem., 1868, 363.
‖ Zeitschr. für Chem, 1869, 176. München. Acad. Ber., ii, 276.
¶ Bericht. der Deutsch. Chem. Gesellsch., vi, 1237.
** Journ. für prakt. Chem., II, iii, 23.
†† Am. Journ., II, xlvi, 289.
‡‡ Ann. Chem. u. Pharm., clxxv, 243.
§§ Journ. für prakt. Chem., II, xi, 352.
‖‖ Am. Journ., III, xi, 195 1876.

fering as they do, in points more or less essential, show that the experimental data are as yet insufficient to establish its structure. In this connection the ethers of uric acid seem to have attracted little attention. In 1864, Drygin* prepared the diethyl and triethyl ethers by the action of ethyl iodide upon diplumbic urate. I have been unable to obtain the original paper, but from the summary of it given in the Jahresbericht† for that year, and in Gmelin's‡ Hand-book, it would appear that he submitted them to no very extended examination. I have, therefore, undertaken the study of the ethers of uric acid, with the hope that a careful study of the products of their decomposition may throw additional light upon the structure of uric acid.

A few preliminary experiments convinced me that the compounds in the methyl series could be much more conveniently made than those of the ethyl or benzyl. I therefore began with the methyl ethers, and this paper gives the results I have obtained in the study of the first of these.

Methyluric acid, $C_5H_3(CH_3)N_4O_3$.

Methyluric acid may readily be prepared by the action of methyl iodide upon monoplumbic urate. The metathesis takes place slowly at 110°–130°, rapidly between 160° and 165°. The dry lead salt mixed with methyl iodide in molecular proportions, enough ether being added to keep the mixture fluid, is heated in sealed tubes for eighteen hours at 165°. After the evaporation of the ether, the product of the reaction is boiled with water, and the solution filtered from the unaltered plumbic urate. The lead is then precipitated with hydric sulphide, and the plumbic sulphide filtered off boiling hot. The filtrate deposits, on cooling, methyluric acid in small crystals. These are dissolved in dilute potassic hydrate, the solution boiled for a few minutes, reprecipitated by hydrochloric acid, and recrystallized from boiling water. The yield is about sixty per cent of the amount theoretically required by the lead salt which enters into the reaction. A portion of the uric acid is completely decomposed, and is found as ammonium salt in the mother liquors and the crude product. I attempted to increase the yield by employing anhydrous ether in the place of common ether. Although no ammonium compounds were then formed, a much smaller percentage of the lead salt entered into reaction. Longer heating at a lower temperature did not increase the yield, inasmuch as a larger quantity of dimethyl ether was then formed. The amount of dimethyl ether formed by heating to 165° is small; and as it is much more soluble in

* Russ. Zeitschr. Pharm., iii, 3, 28, 49, 113, 121.
† Jahresbericht, 1864, 629.
‡ Gmelin, Suppl., ii, 1026.

water than the monomethyl ether, it may readily be removed by recrystallization.

Methyluric acid crystallizes in small clear flat prisms, apparently of the trimetric system, the crystals being often pointed at either end. By slow cooling of a dilute solution, these crystals sometimes reach a length of 2–3 mm., but they are usually much smaller. The substance undergoes no visible change when heated to about 300°; at a higher temperature, it melts with complete decomposition, and without perceptible sublimation. It is soluble in boiling water, almost insoluble in cold water or in boiling alcohol; insoluble in ether. Cold concentrated sulphuric acid dissolves it abundantly; upon dilution it crystallizes out, apparently unchanged.

The substance dried at 165° has the formula $C_5H_3(CH_3)N_4O_3$, as the following analyses show:

1. 0·4284 grm. gave 0·1310 grm. H_2O, and 0·6210 grm. CO_2.
2. 0·2748 grm. gave 0·0985 grm. H_2O, and 0·3972 grm. CO_2.
3. 0·1822 grm. gave 50·0 c.c. nitrogen, at 20°·5, and 754·3 mm. press.

Calculated for		Found.		
$C_6H_6N_4O_3$.		1	2	3
C	39·56	39·53	39·43	
H	3·30	3·39	3·98	
N	30·77			30·98

As the mean of several determinations of solubility, I find that there are required for the solution of one part of methyluric acid 253·6 parts of boiling water, and 4596 parts of water at 20°.

The aqueous solution reddens litmus feebly, and decomposes carbonates readily on heating. A solution in potassic or sodic hydrate is not precipitated by carbonic dioxide. From a concentrated cold solution, stronger acids precipitate it gelatinous, from hot or dilute solutions crystalline.

With bases methyluric acid forms a series of definite salts, some of which have been studied by Mr. O. R. Jackson in this laboratory. The results of this investigation may be found in the Proceedings of the American Academy.* He has analyzed the following salts:

$K_2C_5H(CH_3)N_4O_3 \quad 3\,H_2O$
$KC_5H_2(CH_3)N_4O_3 \quad H_2O$
$Na_2C_5H(CH_3)N_4O_3 \quad 3\,H_2O$
$NaC_5H_2(CH_3)N_4O_3 \quad H_2O$
$BaC_5H(CH_3)N_4O_3 \quad 3\tfrac{1}{2}H_2O$
$Ba(C_5H(CH_3)N_4O_3)_2 \quad 4\,H_2O$
$Ca(C_5H(CH_3)N_4O_3)_2 \quad 3\tfrac{1}{2}H_2O$

These salts show that the monomethyl ether of uric acid is

* Amer. Acad. Proc., xii, 36.

itself a bibasic acid like uric acid; a fact which is certainly remarkable and of obvious theoretical importance.

Action of Hydrochloric Acid.

In 1867, Strecker* showed that uric acid heated with fuming hydrochloric or hydriodic acid to 170° assimilates five molecules of water, giving carbonic dioxide, ammonia, and glycocoll,—

$$C_5H_4N_4O_3+5H_2O=3CO_2+3NH_3+C_2H_5NO_2.$$

The inferences which he drew† from this reaction concerning the structure of uric acid are well known. Emmerling‡ has recently shown that cyanogen gas passed into boiling hydroidic acid is converted into glycocoll, and seeks thus to give Strecker's reaction a new interpretation. In either case, however, it seemed to me of importance to determine the products of the decomposition of methyluric acid under these conditions.

Two tubes, each containing 1·3 grm. methyluric acid, and an excess of hydrochloric acid saturated at 0°, were heated four or five hours at 170°. The gas which escaped on opening the tubes was found to contain no methyl chloride. The excess of acid was driven off on the water bath, and the residue distilled with plumbic hydrate until the distillate was no longer alkaline. The ammoniacal distillate was caught in hydrochloric acid, and evaporated to dryness on the water bath. The residue was treated with a small quantity of absolute alcohol, and the filtered solution again evaporated to dryness. There was then left a white saline residue, which gave with great readiness Hofmann's isocyanide reaction, showing the presence of a monamine. The chloride was converted into the platinum salt, and this was analyzed after recrystallization from hot water.

0·4760 grm. gave on ignition 0·1991 grm. platinum.

	Calculated for $(CH_3NH_3)_2PtCl_6$.	Found.
Pt	41·61	41·82

Methylamine is, therefore, one of the products of the reaction.

From the residue left on distillation, it was easy to isolate glycocoll in the ordinary way. The liquid was filtered from the basic plumbic chloride, the lead removed from the solution by hydric sulphide, and the filtrate evaporated. On standing, glycocoll crystallized out with its characteristic properties. For its identification, it was converted into the copper salt by boiling with freshly precipitated cupric oxide, and precipitation of the blue solution by alcohol. Of this salt,—

* Ann. Chem. u. Pharm., cxlvi, 142; Zeitschr. für Chem.. 1868, 215.
† Zeitschr. für Chem., 1868, 363.
‡ Berichte Deutsch. Chem. Gesellsch., vi, 1351.

0·4400 grm. lost at 130° 0·0388 grm.

	Calculated for $(C_2H_4NO_2)_2Cu \cdot H_2O$	Found.
H_2O	7·85	7·68

A determination of copper in the dry salt gave,—

0·4068 grm. left on ignition 0·1523 grm. CuO.

	Calculated for $(C_2H_4NO_2)_2Cu$	Found.
CuO	37·55	37·43

The reaction in this case may therefore be written,—

$$C_5H_3(CH_3)N_4O_3+5H_2O=3CO_2+2NH_3+CH_3NH_2+C_2H_5NO_2.$$

It will be seen that this reaction proves the commonly accepted view that uric acid is not an hydroxyl but an imide acid.

In order further to establish the relative position of the methyl radical, it seemed to me of chief importance to follow it through oxidation in alkaline and acid solution, and thus determine its relation to allantoin and alloxan or paraban.

Methylallantoin. $C_4H_5(CH_3)N_4O_3$.

Methyluric acid is readily oxidized in alkaline solution, according to the method of Claus and Emde.* The solution must be dilute with but a small excess of alkali, the potassic permanganate added slowly in exact molecular proportion. As soon as the manganese dioxide has separated, it must be filtered rapidly with the aid of the pump, and the filtrate slightly acidified with acetic acid. I then found it most advantageous to evaporate as quickly as possible on the water bath to small volume. After standing twenty-four hours the methylallantoin crystallizes out in clusters of radiated prisms. These separated from the mother liquor by pressure, and recrystallized several times from hot water, form clear distinct monoclinic prisms, closely resembling ordinary allantoin. They are readily soluble in hot water, sparingly in cold; almost insoluble in alcohol, hot or cold, and insoluble in ether. These crystals melt with decomposition at 225°.

In spite of many variations of the method, I could obtain in this way but fifteen per cent of the theoretical yield. From the mother liquors evaporated to a syrup, alcohol separates a potash salt, probably of methylallantoic acid. On account of its uninviting character it was not further examined.

Methylallantoin dried at 100° gave, on analysis,—

* Berichte Deutsch. Chem. Gesellsch., vii, 226.

0·2362 grm. gave 0·1092 grm. H_2O, and 0·2978 grm. CO_2.

	Calculated for $C_4H_5(CH_3)N_4O_3$.	Found.
C	34·89	34·39
H	4·65	5·13

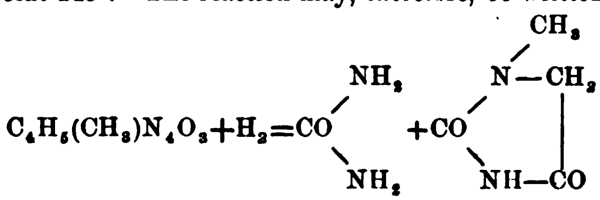
This substance is apparently isomeric with that described by Grimaux under the name Pyruvil.*

Silver nitrate gives in a hot saturated solution on the cautious addition of ammonic hydrate, a crystalline precipitate consisting of needles or short prisms. This salt is readily soluble in hot water, more sparingly in cold. By spontaneous evaporation of the cold solution, tolerably perfect crystals of the trimetric system were obtained. This compound may be dried, without decomposition, at 100°, and gave then on analysis,—

0·1668 grm. left on ignition 0·0646 grm. silver.

	Calculated for $AgC_4H_4(CH_3)N_4O_3$.	Found.
Ag	38·71	38·61

Bäyer† has shown that allantoin, when heated with hydriodic acid, breaks up into urea and hydantoin; and it was evident that methylallantoin should give an analogous reaction. I therefore heated methylallantoin with concentrated hydriodic acid, following the directions given by Bäyer.‡ When the reaction appeared to be ended, the liberated iodine was reduced with sulphide of hydrogen, and the hydriodic acid removed by plumbic carbonate. The filtrate gave on evaporation, after standing for some time, clear crystals, which, freed from the syrupy mother liquor, and recrystallized from water, formed transparent prisms, readily soluble in water or alcohol, and giving no precipitate with zincic chloride. Their melting point I found to be 144°–145°. The quantity at my disposal was insufficient for analysis, but there can be no doubt of the identity of this substance with methyl hydrantoin described by Neubauer§ as resulting from the action of baric hydrate upon creatinine, inasmuch as he gives these properties and the melting point 145°. The reaction may, therefore, be written,—



* Berichte Deutsch. Chem. Gesellsch., vii, 1790.

† Ann. Chem. u. Pharm., cxvii, 178. ‡ Ibid., cxxx, 158. § Ibid., cxxxvii, 288.

Once, as the action of the hydriodic acid was longer continued, I obtained a substance crystallizing in broad rhombic plates, readily soluble in water, sparingly soluble in alcohol, which gave a precipitate with an alcoholic solution of zincic chloride. These crystals melted at 105°, and sublimed readily at 100°. They were evidently sarcosine formed from the decomposition of methylhydantoin.

Oxidation of Methyluric Acid with Nitric Acid.

By the oxidation of methyluric acid with nitric acid, a solution is obtained which gives a deep red coloration on warming with ammonic hydrate. From this solution, however, I have as yet been unable to isolate a crystalline product. By spontaneous evaporation in the air, a sticky syrup is obtained, which does not solidify, even after long standing *in vacuo* over sulphuric acid. Alcohol dissolves this residue, the solution remains clear after the addition of ether, and on evaporation again leaves an uncrystallizable syrup. I have been equally unsuccessful in separating by stannous chloride or sulphide of hydrogen a crystalline alloxantine or dialuric acid. Oxidation with potassic chlorate and hydrochloric acid, according to the method of Schlieper,* gave the same result. These reactions were sufficient to give a qualitative proof that the solution did not contain ordinary alloxan. I therefore attempted to prepare from this solution a methylalloxanate in form fit for analysis. I first tried with baric hydrate to form the barium salt. The ordinary method, following closely the directions of Schlieper,† gave me, however, a salt containing but a trace of nitrogen and with percentages of barium, carbon, and hydrogen, closely approximating those required by a basic baric mesoxalate, $BaC_3O_5.BaO_2H_2$. At the same time a strong smell of methylamine was perceived. If a smaller quantity of baric hydrate were added in the cold, and then alcohol in excess, a barium salt was thrown down which contained nitrogen, but it could not in this way be obtained of constant composition. Plumbic hydrate seemed to determine the formation of the methylalloxanate, but no better results were obtained. The silver salt blackened too rapidly to admit of analysis.

The lime salt is the only one I have been able to prepare with constant composition. Methyluric acid is dissolved in as small a quantity of nitric acid of 1·42 sp. gr. as possible, the solution somewhat diluted, and the excess of acid neutralized with calcic carbonate in the cold. The solution is then allowed to stand *in vacuo* for some time, to free it from carbonic dioxide, afterwards diluted with six or eight volumes of alcohol and filtered. The cautious addition of ammonic hy-

* Ann. Chem. u. Pharm, lv, 261. † Ibid., 272.

date to the filtrate throws down a bulky semi-gelatinous precipitate, which, well washed with alcohol, and dried at 100°, forms an amorphous powder, which has a faint pink color,—undoubtedly caused by a trace of alloxan. The dry salt was soluble in cold water, though with some difficulty.

Analysis gave for substance dried at 100°—

1. 0·1778 grm. gave 0·1125 grm. $CaSO_4$.
2. 0·2275 grm. gave 0·1446 grm. $CaSO_4$.
3. 0·3049 grm. gave 36·8 c.c. nitrogen at 21°·5, and 762·1 mm. press.

	Calculated for $C_4H(CH_3)N_2O_5Ca$	Found. 1	2	3
Ca	18·87	18·61	18·69	
N	13·21			13·68

The analyses 1 and 2 were made with different preparations.

Inasmuch as the chief point was to prove the formation of methylalloxan by this oxidation, I distilled the calcium salt, prepared in the manner described, with potassic hydrate in a current of steam. The ammoniacal distillate readily gave the characteristic isocyanide reaction by heating with alcoholic potash and chloroform. It was neutralized with hydrochloric acid, evaporated, and from the residue the methylamine chloride separated by absolute alcohol. An analysis of the platinum salt gave—

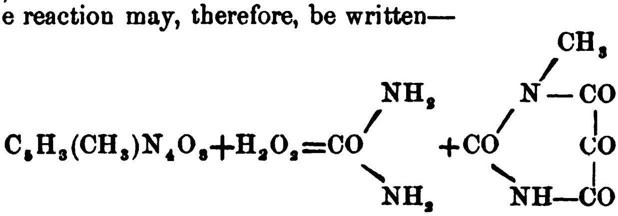
0·2160 grm. left on ignition 0·0902 grm. platinum.

	Calculated for $(CH_3NH_3)_2PtCl_6$	Found.
Pt	41·61	41·76

Thus proving that the calcium salt contained the group $=N-CH_3$.

In further confirmation, I was able to isolate common urea as the secondary product of the methylalloxan formation. After oxidizing with hydrochloric acid and potassic chlorate, the excess of acid was driven off by evaporation at gentle heat, the potassic chloride separated with absolute alcohol, and the alcoholic solution evaporated to a syrup. The cautious addition of strong nitric acid caused the separation of abundant crystals of urea nitrate in characteristic form. The base, set free as usual with baric carbonate, after recrystallization from water, melted at 129°-130°.

The reaction may, therefore, be written—



Methylparaban, $C_3H(CH_3)N_2O_3$.

Although methylalloxan is so unstable in the presence of bases, in acid solution it possesses remarkable stability. It may be boiled for some time with strong nitric acid, or with hydrochloric acid and potassic chlorate before the red coloration with ammonia disappears. On prolonged boiling (about an hour) with strong nitric acid, the oxidation is complete, and the solution contains methylparaban. For its preparation I have found it most advantageous to boil methyluric acid with five or six parts of nitric acid of sp. gr. 1·3, until a drop taken out gives no coloration with ammonia. The excess of acid is then driven off on the water bath, the syrupy residue diluted with a little water, and well shaken out with ether. On distilling off the ether, a syrup remains which soon crystallizes in shining radiated prisms, which are recrystallized from hot water. They are somewhat difficultly soluble in cold water, readily in hot; soluble in alcohol and ether. The substance melts at 149°·5, sublimes very slowly at 100°, and at higher temperature with great readiness. For analysis, the air-dried substance was heated three hours at 100°; during that time 0·2260 grm. lost 0·0030 grm.

1. 0·1714 grm. gave 0·2333 grm. CO_2.*
2. 0·2160 grm. gave 0·0785 grm. H_2O, and 0·2629 grm. CO_2.

	Calculated for $C_4N_2H_4O_3$	Found. 1	2
C	37·50	37·12	37·48
H	3·13		4·04

The substance gives no precipitate with calcic chloride, even after the addition of ammonic hydrate. On warming the ammoniacal solution, a precipitate falls not wholly soluble in acetic acid. Argentic nitrate precipitates it only in concentrated solution. The silver salt prepared from concentrated solution, with the cautious addition of ammonic hydrate, crystallizes in prismatic needles; quite readily soluble in hot water, sparingly in cold. Under the microscope it crystallizes from hot aqueous solution in rhombic plates. It may be dried at 100° without decomposition. It gives on analysis,—

0·1210 grm. left on ignition 0·0556 grm. silver.

	Calculated for $AgC_4N_2H_3O_3$.	Found.
Ag	45·95	45·95

There can be no doubt that this substance is identical with that obtained by Dessaignes† from creatinine, which was first recognized by Strecker‡ as methylparaban. Dessaignes gives

* The hydrogen in this analysis was lost.
† Ann. Chem. u. Pharm., xcvii, 343. ‡ Ibid., cxviii, 164.

no melting point, but the description given corresponds perfectly with the substance I have obtained; the only difference being that I find the substance quite readily soluble in ether, whereas he gives it as somewhat soluble only.

Although I must postpone all discussion of the structure of uric acid until the investigation upon which I am at present engaged is farther advanced, I may perhaps be pardoned if I consider briefly the structure of urea which must of necessity form the foundation of any formula of uric acid. It certainly would not have occurred to me that any such consideration of its structure were necessary had not Professor Mallet in his recent paper on uric acid and its derivatives in this Journal,* adopted the formula $C\begin{matrix}NH_2\\NH\\OH\end{matrix}$, which was proposed several years ago at about the same time by Wanklyn and Gamgee† and Gibbs.‡ Professor Mallet hardly discusses in his paper the facts bearing upon its structure, but contents himself with pointing out the simplicity which he believes this formula will give to its complex derivatives,—a style of argument serviceable enough, where there is little or no choice upon other grounds, but certainly not to be trusted, if opposed by direct synthetic reactions.

The facts remain, as far as I know, essentially as they were when the whole matter was reviewed by Heintz.§ Basarow‖ proved in Kolbe's laboratory the formation of urea from ammonic carbonate and carbamate. Natanson¶ showed that it was formed by the action of ammonia upon carbonyl chloride and ethyl carbonate, and his results were afterward confirmed by Neubauer and Kerner.** By these syntheses urea is shown to be directly connected with carbonic acid as its amide by the three principal general reactions for the formation of amides, and no formula but $CO\begin{matrix}NH_2\\NH_2\end{matrix}$ can explain these reactions without the gratuitous resort to molecular rearrangement. Very recently the reaction with carbonyl chloride has been employed by Michler†† in the formation of fourfold substituted ureas: $CO\begin{matrix}Cl\\Cl\end{matrix}+\begin{matrix}HN(C_2H_5)_2\\HN(C_2H_5)_2\end{matrix}=CO\begin{matrix}N(C_2H_5)_2\\N(C_2H_5)_2\end{matrix}+2HCl$, leaving no possible doubt of the symmetrical distribution of the hydrogen atoms in urea.

Against these syntheses but two facts have been urged:

* This Journal, March, 1876, p. 185. † Journ. Chem. Soc., II, vi, 25.
‡ This Journal, Nov., 1868, p. 289. § Ann. Chem. Pharm., cl, 67.
‖ Zeitschr. für Chem., 1868, 204. ¶ Ann. Chem. Pharm., xcviii, 287.
** Ann. Chem. Pharm., ci, 342. †† Berichte Deutsch Chem. Gessell., vii, 1664.

first, the monobasic character of urea, and secondly Wanklyn and Gamgee's oxidation with alkaline permanganate.

As for the basicity of urea, Heintz* has already shown that basicity does not always correspond to the number of amide nitrogen atoms, and that amidogen, like hydroxyl, is largely dependent for its character upon the nature of the radical to which it is attached. As especially pertinent he instances oxamide, which is neutral although undoubtedly a diamide. An entirely different case in its nature, although perhaps still more to the point is guanidine $C\begin{matrix}NH_2\\NH\\NH_2\end{matrix}$, which is monobasic only. According to every analogy, therefore, the observed basicity of urea is but the normal behavior of carbamide.

The experiments of Wanklyn and Gamgee† were five in number. Two were made upon urea, two upon ammonium salts, and one upon acetamide. They found with an excess of permanganate that urea gave up all its nitrogen as gas, while the nitrogen of the ammonia and of acetamide was oxidized to nitric or nitrous acid. It may well be questioned, I think, whether these results are sufficient to form the basis of any generalization as to the behavior of "admitted amides," still granting that urea is thus distinguished from all other amides the proof is yet to be brought that the formula $C\begin{matrix}NH_2\\NH\\OH\end{matrix}$ possesses any advantages in explaining this observed decomposition. What experimental facts, what analogies, what plausible theory even can be given to justify the assumption that the nitrogen atoms in $CO\begin{matrix}NH_2\\NH_2\end{matrix}$ and $C\begin{matrix}NH_2\\NH\\OH\end{matrix}$, under the conditions employed by Wanklyn and Gamgee, would differ so fundamentally in their behavior? Anomalous as the decomposition of urea may be, it certainly is not to be explained by so simple a device as the substitution of one imide nitrogen for an amide. If this anomalous behavior should be established by further investigation of other diamido compounds, it would not be the first case in which the mono-carbon compounds differed essentially from their higher homologues.

I have thus briefly given my reasons for dissenting from Professor Mallet's assertion that the structure of urea is by no means settled. I can not but think it established by evidence as unequivocal as our present methods of research are capable of giving.

* Loc. cit., p. 74. † Journ. Chem. Soc., 1868, p. 25.

Harvard College Laboratory, Sept., 1876.

ART. XLVII.—*Notice of a Meteorite, from Madison Co., N. C.*; by B. S. BURTON, University of East Tennessee.

THIS meteorite was placed in my hands for examination by Professor F. H. Bradley, who also furnishes the following facts in regard to its history:

"The mass was found in August, 1873, on land of Robert Farnesworth, near Duel Hill, Madison Co., North Carolina. It was lying on a hillside where it had been used, probably, by the first settlers of the land in supporting a corner of a rail fence, now rotted away. It is said to have weighed, when first found, about twenty-five pounds. Two or three pounds of 'specimens' had been hammered off before I secured it, most of which could not be recovered. Mr. Farnesworth reported that a similar mass weighing about forty pounds had been found about a mile farther west, before the war, perhaps about 1857, which had since disappeared, probably has become buried in rubbish. Efforts to find it again were unsuccessful."

This meteorite consists of metallic iron, of a rounded irregular shape, with the usual coating of magnetic oxide, and measuring $9 \times 6\frac{1}{2} \times 3\frac{1}{2}$ inches, and weighed twenty-one pounds. Over the surface at various points was a small bead-like deliquescence of iron chloride. A portion was cut off at a machine shop, though only after considerable trouble, and described by the machinist as "the toughest piece of iron" he had ever handled. After polishing, and by the action of acid, the usual markings appeared, though rather indistinct; and, at the same time, were developed distinct particles of Schreibersite irregularly disseminated over the surface, which by continued action of the acid stood out more prominently.

Specific gravity $= 7{\cdot}46$. Iron not passive. Dissolves in hydrochloric acid, without liberating sulphuretted hydrogen, leaving a very slight, black, carbonaceous residue, which contained SiO_2, Fe, Cr, Ni, P.

The following result was obtained on about one gram of the iron:

Iron	94·24
Nickel	5·17
Cobalt	0·37
Phosphorus	0·14
Copper	trace
Residue	0·15
	100·07

Art. XLVIII.—*On a Recent Discovery of Carboniferous Batrachians in Nova Scotia;* by J. W. Dawson, LL.D., F.R.S.

1. *General Remarks.*

The erect Sigillariæ enclosed in the sandstone overlying coal-group 15 of Section XV, Division 4 of the South Joggins section, are perhaps the most remarkable repositories ever discovered of the remains of Paleozoic land animals. As I have shown in discussing their character in my memoirs on the South Joggins Coal Formation,* and my "Acadian Geology," some of these trees became embedded in sandy deposits, and being rendered hollow by decay of their inner bark and the crumbling of their woody axes, remained for a long time as open holes or pits, gradually filling with vegetable debris and the wash of rains and land floods. They thus became places of habitation for land snails and millepedes, and pit-falls into which the smaller batrachians, prowling for prey among the undergrowth of the coal forest, fell and were unable to extricate themselves. In this way the successive layers of deposit became stored with skeletons of batrachians which they have retained in an admirable state of preservation.

Only one sandstone at the Joggins is known to contain these reptiliferous trees, though erect Sigillariæ are known at more than sixty different levels, and many of these erect stumps have been broken up in the hope of making such discoveries. In the past summer, however, shells of *Pupa vetusta* were found by Mr. Albert J. Hill and the writer in an erect tree in Section XXVI of Division 4, about 800 feet higher in the series; and of course where these shells occur remains of other land animals may also be discovered.

Since the discovery by Sir Charles Lyell and the writer of the remains of *Dendrerpeton Acadianum* in one of the erect trees of group 15, I have several times visited the locality, and have endeavored to take advantage of the exposure of new trunks by the encroachments of the sea. In the summer of 1859 I took down a second stump which afforded nine skeletons of four species, as well as remains of Millepedes and shells of Pupa. In 1860, I dissected two other stumps, which yielded six additional skeletons including two new species. In the whole six batrachian species were more or less perfectly represented, and were described by Prof. Owen or myself. Mr. Scudder subsequently made a careful study of the remains of Millepedes, and referred them to five species belonging to two genera.† In the present year another tree very richly stored

* Journal of Geological Society of London, vols. ix, x, xi, xvi, xviii, xix.

† Air-breathers of the Coal Period, 1863. Acadian Geology, 1868, pp. 362 and 495. Scudder in Memoirs of Boston Soc. of Nat. History, 1873.

with remains was obtained, and its contents will form the subject of the present communication. Two others were extracted for me by the kindness of Mr. Hill, superintendent of the Cumberland Mine, but proved to be filled merely with sandstone without animal remains. This is an illustration of the fact that, even in this bed, only certain trees remained open long enough to become burial places of land animals.

All the remains found in these singular repositories are those of air-breathing animals, except certain worm-like bodies of uncertain nature, which Mr. Scudder suggests may be remains of Leeches. Further, as the reptiles which fell into these pits could have been only such as were capable of walking on land, the erect trees contain none of the ichthyic and elongated forms which have been described from Ireland, from Germany and from Ohio.* Such forms no doubt existed in Nova Scotia, but could not be laid up in coffins formed of Sigillaria trunks. The species preserved in these are therefore all of more or less lizard-like form, and have well developed limbs. Some of them, as we shall find, are also remarkable for ornate cuticular appendages, more akin to those of modern lizards than to those of batrachians. Again, though we know from the footprints of *Sauropus unguifer*,† found in Cumberland County at no great distance from the Joggins, and from those of *Sauropus Sydnensis*‡ found in Cape Breton, as well as from the osseous remains of the alligator-like *Baphetes*, that there were large terrestrial Labyrinthodonts in the coal swamps of Nova Scotia, these were of course too bulky to fall into the erect Sigillariæ; consequently the remains found are those of the smaller species only.

The state of preservation of the specimens is also peculiar. All the bones of each specimen are sure to be present; but inasmuch as most of the carcases had time to decay completely before they were finally covered up, the bones are often much scattered, and have apparently fallen into the interstices of the vegetable fragments on which they lay, so that the skeletons are usually disarticulated, and the bones, though individually perfect, are so entangled in the matrix that it is impossible to uncover the whole of them. In other, though rare cases, the body seems to have been covered at once, and its soft parts, and especially the skin, being either preserved by the tanning action of the vegetable matter, or converted into adipocere, remain in a coaly state, and completely cover the bones, so that these cannot be extracted except in fragments and by the destruction of the cuticle which invests them. Thus, while these remains afford the greatest facilities for the detailed and

* By Huxley, Von Meyer and Cope. † Geological Magazine, vol. ix.
‡ Acadian Geology, p. 358.

even microscopic examination of the parts, they do not often furnish skeletons with their members *in situ*, as in many of those described by Von Meyer, Huxley and Cope.

The tree of 1876 was found by me in "the reef" or extension of the sandstone seaward, and near the low-water mark. The upper part of the stump, probably filled with sandstone, had been removed by the waves, but about two feet of the lower part remained. It was extracted with as much care as possible by two miners with picks and crowbar, and the disk-like fragments, into which it naturally split, were carried up to the foot of the cliff and subsequently numbered and dissected at leisure. In the hurry of working against time to escape the tide, the men it seems left in the hole a portion of the lowest layer, and a fragment of an upper one. The former was afterwards removed by Mr. J. C. Russel of Columbia College, New York, and the latter was found by Mr. Hill. Both have been kindly placed in my hands by these gentlemen, so that the whole of the material has been collected and carefully labelled, in such a manner as to keep together the parts belonging to each skeleton.

This tree was about eighteen inches in diameter, and in the lower part was partially flattened by lateral pressure, so that its diameter in one direction was only a little over a foot. The material filling the somewhat thick coaly bark may be described as a more or less arenaceous silt or soil, blackened with vegetable matter, and replete with fragments of carbonized bark, mineral charcoal and fine vegetable debris. There are also numerous leaves of *Cordaites*, and abundance of the fruits which from their frequent occurrence in such hollow trees, I have elsewhere named *Trigonocarpum sigillariæ*. In some places the sediment was finely laminated, the laminæ being often much contorted. In other places the earthy matter existed in patches or interrupted layers, nearly free from vegetable matter, and especially abundant toward the sides of the trunk. The cementing substance is in general carbonate of lime, many portions of the mass effervescing freely with an acid, but in some spots there are hard concretions of pyrite. The material has evidently been introduced gradually, in small quantities at a time, and the earthy matter seems to have run down the sides, spreading more or less toward the center; but in general accumulating around the circumference. The number of skeletons recovered in a more or less complete state was no less than thirteen in all, belonging probably to six species, besides other bones contained in Coprolites, and several Millepedes, and shells of *Pupa vetusta*, the latter almost entirely in the lowest layers.

The first animal introduced was a specimen of *Hylerpeton Dawsoni* Owen, whose bones and scutes, after decay of the

connecting parts, had slid down the slope of silt from one side toward the center of the space. Next, after a few inches of filling, came a specimen of *Dendrerpeton Acadianum* Owen, whose bones lie along the center of the layer and nearly in one plane. Above this a large flake of bark had fallen in, forming an imperfect floor over the remains. Then, after an inch or two of carbonaceous matter had been deposited, came a somewhat flat surface which seems to have remained uncovered for some time, and on this lie the *disjecta membra* of three skeletons belonging to *Dendrerpeton Acadianum*, *D. Oweni*, and a new species of *Hylerpeton*. Above this was a confused mass of considerable thickness, in which were found another specimen of the new *Hylerpeton*, and remains representing a third animal of the same or an allied genus, also four specimens of *Hylonomus Lyelli*, and portions apparently of an immature *Dendrerpeton*. Still higher in position, was a layer with large portions of the cuticle of a *Dendrerpeton*, probably *D. Acadianum*; and above this, at the surface of the stump, were some remains and impressions of bones probably indicating another specimen of *Dendrerpeton*. Taking these specimens in the order above given, we may notice the new facts which they have disclosed on a preliminary examination.

2. *Remains of Hylerpeton.*

The sole species of this genus heretofore known, *H. Dawsoni*, was discovered by me in 1860, and was described by Professor Owen from remains so scanty that he expressed considerable doubt as to its affinities. I afterward worked out, from a few fragments of the matrix, the evidence that its teeth were simple, without plicated dentine, that it had a large canine or tusk in the anterior part of the upper jaw, and that it possessed a walking foot. The present specimen throws much additional light on its structure. It had at least twelve teeth in each ramus of the mandible, and they are large in proportion to the size of the animal, bluntly conical and somewhat acuminate, and faintly striate at the apex. The vomerine bones are beset with numerous small blunt teeth. The skull is long, and its bones thin and marked merely with delicate incised lines rather than wrinkles. The forms of the stout ribs and scattered vertebræ would indicate that the body was broad and squat. The skull must have been about two inches in length, the body probably four or five, and there are some small vertebræ which may indicate a short tail. The limbs were large and strong, the femur being an inch and a quarter long, and its shaft a fifth of an inch in diameter and with thick bony walls. The vertebræ are short and biconcave, and with large dorsal spines, the belly was protected by numerous imbricated bony scales of two

kinds, one oblong and narrow, the other broad and obliquely shield-shaped. There are indications of thoracic plates of larger size than the scales. On the whole this species was probably a somewhat clumsy creature, of toad-like form and slow gait, and with a dentary apparatus suited to pierce and crush crusts and shells. It is perhaps significant of its habits, in these respects, that the layers of this tree in which its bones occur are alone those in which shells of *Pupa vetusta* are found.

The second species of *Hylerpeton*, which I may provisionally name *H. longidentatus*, was of somewhat smaller size, with the bones of the skull thinner and more slender, and the teeth very long and sharply pointed, with the apex finely striate but with no corrugation of the dentine. The vomer is covered with minute teeth, and there are long and slender canines. The best preserved mandible shows eighteen teeth which are strongly inclined backward. The scales are very narrow and there is a large thoracic plate. The general form of body may have been as in the last species, but the skull was probably narrower and the feet longer.

Another species of this genus, or belonging to a genus intermediate between it and *Hylonomus*, is represented by a confused mass of bones showing long and narrow jaws, armed with short and blunt teeth, of which, at least thirty occur on each side of the lower jaws. The sculpture of the bones is as in the previous species, but the pulp-cavities of the teeth are smaller and their walls stronger, and they show no sculpture on the apex; in which respects they resemble those of *Hylonomus*. The vertebræ also are more elongated and the femur is a large bone indicating a powerful hind limb. The abdominal scutes are very long and narrow, resembling slender semi-cylindrical rods, a point in which this species differs from all the others found with it, although it resembles some of those found in Ireland and Ohio. This species I would name provisionally, in allusion to the form of its teeth, *Hylerpeton curtidentatum*.

In all these species of *Hylerpeton*, the teeth are simple, and are anchylosed to the bone and placed in linear series in a shallow groove.

3. *Remains of Dendrerpeton.*

The remains of this genus will afford additional facts as to the differences in individuals of various ages, and as to the details of the skeleton in the species *D. Oweni*, previously known by only one imperfect example. The specimen now found would seem to show that it resembled very much the larger species, except in the form of the teeth and scales. But the most interesting facts presented by a cursory examination of the specimens relate to the skin and its appendages. It is

now evident that in addition to the abdominal and gular scales, *Dendrerpeton* possessed thoracic plates of considerable size, resembling those of other Labyrinthodonts. The large mass of skin found in the tree of 1876, taken in connection with the smaller portions found on previous occasions, and described in detail in my "Air-breathers of the Coal-period," enables us to form a very good general idea of the appearance and clothing of the animals of this genus. To the naked eye the skin presents a shining and strongly rugose surface, reminding one of that of modern newts when contracted by immersion in alcohol, though on a coarser scale. Under the lens, the surface appears granular and with a higher power the granulation is seen to result from minute scales imbedded in the cuticle, and much smaller than those, in previous finds, which I have referred to *D. Oweni* and to *Hylonomus.* On some portions of it there are delicate transverse lines about a quarter of an inch apart, and apparently corresponding to those which on the newts and Menobranchus mark the bands of subcutaneous muscles. The bony scales of the abdomen have disappeared, except a few scattered in the matrix. But the most remarkable dermal appendages, are those triangular lappets or frills of which I have in previous papers described detached examples, and have compared them with the gular and cervical lappets and frills of iguanas, geckos and Draco; and which also suggest analogies with the processes that support the gills in perennibranchiate batrachians, and with the lateral folds of the skin in Menopoma. These appendages are flat and of appreciable thickness, about half an inch in length, and an eighth of an inch in breadth, terminating in an edge or obtuse flat point, which seems to have been horny, while the appendage itself must have been flexible. They are marked with small scaly oval areoles or projections, placed somewhat in rows, and each with a minute puncture in its center. The markings on both sides are similar. These appendages are arranged in series along what appears to be the skin of a fore leg, and also in groups apparently on the anterior part of the body, perhaps the neck or shoulder. They appear to be closely connected with a series of much smaller angular points which extend along the edge of the skin near the supposed leg, and probably fringe the sides of the abdomen. The evidence that this integument belongs to *Dendrerpeton Acadianum* is derived from the presence in its anterior part of skull-bones having the markings of that of this species, and from the occurrence of a jaw and other bones in the neighboring matrix. The specimen to which the skin belonged may have been about a foot in length. Taking it in connection with what is known of the skeleton, we can reproduce the external appearance of the animal. It was

lizard-like in form, with a somewhat flat and broad head and strong teeth with folded dentine. Its back was covered with a shining skin filled with microscopic horny scales. Its sides were marked by vertical bands separated by delicate indented lines. Anteriorly it was ornamented with numerous cutaneous lappets or pendants. The sides were bordered with a row of sharp horny points, and the throat, thorax and abdomen were protected by bony scales and plates, the scales of the throat being narrow and small and arranged in a chevron pattern.

Dendrerpeton Oweni probably had the scales of the back and the horny appendages larger in proportion, that is, if I have rightly referred to that species some similar remains to those above mentioned, found in 1859. *Hylonomus Lyelli* had a far more ornate set of cutaneous appendages, as evidenced by remains of skin found associated with its bones, also in 1859.* The tree of 1876 contains no cuticular remains referable to these species.

4. *Remains of Hylonomus.*

The bones of this genus are all, I think, referable to *H. Lyelli*, and to specimens about the size of those previously found. They throw little additional light on its character, except to indicate that it was probably very abundant, and to render it probable that the specimens formerly described were adult. Two of the skulls in the tree of 1876 are better preserved than those previously known, and confirm the statement already made as to the smoothness of the bones and the greater cranial elevation as compared with other batrachians of the Carboniferous period. This is indicated, among other things, by the skulls lying upon one side, which is not found to be the case with the other species.

In the admirable Report by Cope on the Batrachians of the Coal-formation of Ohio,† he places *Hylonomus* in the same family, *Tuditanidæ*, with *Dendrerpeton*. This I think does not express its true affinities. The more elongate and narrow skull, with smooth bones, the differently formed vertebræ, the teeth with non-plicated dentine, the different microscope structure of the bone, the more ornate dermal appendages, all separate these animals from the Labyrinthodonts, and entitle them, as I have formerly held, to a distinct position as an order or sub-order, for which I proposed in 1863 the name *Microsauria*. I observe that in the report on the Labyrinthodonts prepared by Mr. Miall for the British Association in 1873, and in the Tabular View appended to it in 1874, while the group *Microsauria* is retained, *Dendrerpeton* is placed in it, as well as *Hylerpeton*

* Journal Geol. Soc., vol. xvi, also "Air-breathers," 1863.
† Paleontology of Ohio, vol. ii.

and *Hylonomus.* This I think is an error in so far as the first genus is concerned. I may add my continued conviction that *Hylonomus* and its allies present many points of approach to the lacertian reptiles, which I hope in future to be able to work out more in detail.

Several masses of Coprolite, filled with small broken bones, were obtained in breaking up the material surrounding the skeletons. I presume these bones belong to one or other of the smaller species of *Hylonomus;* but I have not yet found any of them to be sufficiently characteristic to warrant any confident statement on the subject. These Coprolites must have been produced by *Dendrerpeton* or *Hylerpeton*, most probably the former.

The above statements must be regarded as imperfect, and preliminary to more detailed description and illustration of the specimens. These will require long and patient work and microscopic examinations of the bones and the teeth, and when this is completed they will be placed in relation, as far as possible, with the remains previously found in Nova Scotia, and with what is known of coal batrachians elsewhere.

I think it quite possible that further examination may enlarge the number of species above mentioned. I have been guided mainly in the reference of the specimens to species by the structure of the teeth and the cranial bones; but some of these may yield new points of difference on further study. As all the specimens are preserved under the same conditions, there is less liability here, than in most cases, to multiply species unduly, in consequence of different states of preservation.

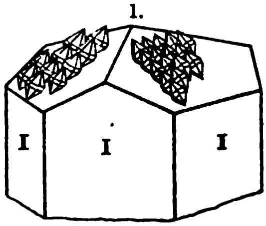
The fact that Cope has been able to catalogue, in his recent Report,* 39 genera of Carboniferous batrachians, including about 100 species, and that these present so wide a range of size, structure and general conformation, affords a very remarkable illustration of that simultaneous occurrence of many forms of one type, which appears in so many other groups of fossil animals; and is particularly striking in this first known group of air-breathing vertebrates, which since 1843 have swarmed upon us from the coal-fields of both continents, and of which we probably know as yet but a small fraction of the species. It remains to be seen whether the Devonian, so rich in its land flora, and which has already afforded remains of insects, may not disclose some precursors of the Carboniferous batrachians.

* Paleontology of Ohio, vol. ii.

ART. XLIX.—*Mineralogical Notes.* No. IV; by EDWARD S. DANA, Ph.D.—*On the association of crystals of Quartz and Calcite in parallel position, as observed on a specimen from the Yellowstone Park.*

THE occurrence of crystals of quartz in parallel position upon the faces of a rhombohedron of calcite was long since described by Breithaupt. The relation of the two minerals is shown in figure 1, given by him; each crystal of quartz has its pyramidal face parallel to the rhombohedron ($-\frac{1}{2}R$) of the calcite. Breithaupt also mentions specimens in which the calcite had been removed, and the resulting form he speaks of under the head of *pseudomorphs* of quartz after calcite, as a "trilling" of quartz.*

1.



A somewhat analogous case was described by Rose† and Eck‡ from Reichenstein in Silesia; more recently vom Rath and Frenzel§ have given a full description, illustrated by a number of figures, of a similar occurrence from Schneeberg, Saxony. In the specimens described by them the calcite rhombohedron ($-\frac{1}{2}R$) was completely enveloped by the quartz. Each rhombohedral face of the former having upon it a pyramid of quartz, united by a pyramidal face, and the extension of these six crystals regularly had produced a form which with its reentering angles appeared to be a trilling (a compound crystal of three combined crystals) of quartz. It was further shown by vom Rath that the calcite alone had determined the position of the quartz crystals, and consequently that the form, which had resulted, was only a *pseudo-trilling*. Both the vertical twinning-plane, and the horizontal plane of the compound crystal were pronounced to be impossible forms with quartz.

Many cases of the association of crystals of different species in parallel position have been observed (as for example, of albite on orthoclase, of pyroxene on hornblende, of chrysolite and humite, etc.), but the case here mentioned is of an exceptionally anomalous character. It is a matter of some interest, therefore, to note the discovery of a new case of this association of quartz and calcite and one which offers some features not before observed, affording at least a partial explanation of this geometrical relation between the two minerals.

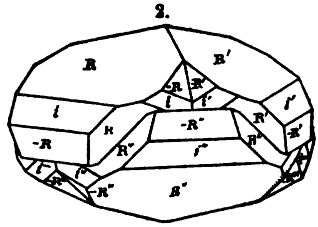
* Berg- u. Hütten. Zeit., 1861, 54.
† G. Rose, Pogg. Ann., lxxxiii, 461.
‡ H. Eck, ZS. G. Ges., xviii, 426.
§ Pogg. Ann., clv, 17, 1874.

The specimen in hand was obtained by the writer in August, 1875, when visiting the Yellowstone National Park in connection with the party of Col. William Ludlow, U. S. A. It was found in the neighborhood of what has been called "Specimen Mountain," a locality which has furnished many fine amethysts, geodes of chalcedony, and fragments of silicified wood. The rock is an igneous conglomerate.

The specimen itself consists mostly of chalcedony, upon the surface of which have been implanted rhombohedrons ($-\frac{1}{2}R$) of calcite, and finally, as a still later process, the quartz has incrusted both the calcite crystals and simultaneously the exposed surfaces of the chalcedony. In the latter position a simple drusy surface of fine quartz crystals, irregularly planted, has resulted, but the crystals upon the calcite, though unquestionably of simultaneous formation, are all in a similar parallel position, analogous to that shown in fig. 1; the pyramidal faces of the quartz crystals (R or $-R$) being parallel to the rhombohedral ($-\frac{1}{2}R$) face of the underlying calcite. In some cases a collection of small parallel crystals of quartz form a coating upon each rhombohedral face, but more generally these crystals are so developed as to be united, forming perfectly smooth continuous faces parallel to those of the calcite. Some of the crystals of calcite are half an inch or more in length, and the continuous layer of quartz has a thickness of about $\frac{1}{2}$ mm., completely enveloping them. This coating may be readily removed, leaving the calcite crystal entire. The completed form, as remarked by vom Rath, has a most anomalous appearance, and one likely to puzzle the careless observer.

The general appearance of the crystals is very uniform; it is shown in fig. 2. In the smaller crystals ($\frac{1}{8}$ to $\frac{1}{4}$ inch broad), the symmetry of the planes was nearly as perfect as in the drawing. A comparison of this figure with those given by vom Rath will show that though in the main features similar, still the one here given differs in some most important respects.

2.



The first examination of the crystals suggests the probable existence of the zones (fig. 2) i, $-R$, $-R'$, i'; also i, R, R'', i'', $-R''$, $-R^{iv}$; and i', R', R'', i'', $-R''$, $-R'''$. The three cases as they are continued around the crystal are obviously repetitions of the same series of planes. A more critical study of them, however, by the aid of the reflecting goniometer, shows that they are really only *pseudo-zones*, although it is seen at the same time that the deviation from perfect parallelism is very slight. It is in fact a remarkable case of *pseudo-symmetry*.

The following angles were measured in these "zones," as they may for convenience be called. A double-telescope goniometer was employed for the purpose, though the character of the planes was not such as to allow of the highest degree of accuracy.

1. Zone i, $-R$, $-R'$, i'

$i \wedge -R = 113° \ 12'$	$i \wedge -R' = 143° \ 48'$	$-R \wedge -R' =$	$149' \ 28'$
$i' \wedge -R' = 113° \ 10'$	$i' \wedge -R = 143° \ 45'$	$i \wedge i' =$	$77° \ 29'$

2. Zone i, R, R'', i'', $-R''$, $-R^{\mathrm{iv}}$

$i \wedge i'' = 102° \ 8'$	$R \wedge R'' = 124° \ 2'$	$-R'' \wedge -R^{\mathrm{iv}}$	$149° \ 13'$

Supposing for the moment that the two series of planes mentioned are true zones, and also that, as appears at first sight to be the case, the whole crystal is a complex *twin*, it is obvious that the twinning-plane for the two upper crystals of quartz must be a plane in the zone i, $-R$, etc., and must either halve the angle $i \wedge i'$, or which is the same thing $-R \wedge -R'$, or else be normal to this bisecting plane. Similarly, for either crystal above and the one diagonally below, the twinning-plane must also lie in the zone i, $+R$, etc., and must be either that plane which bisects the angle $i \wedge i''$, and $R \wedge R''$, or one at right angles to it.

For the first case the measured angle of $-R \wedge -R' = 149° \ 28'$, gives $38° \ 24'$, that is, $141° \ 36'$ or the angle between the twinning-plane and the prism i. Again, the measured angle $77° \ 29'$ for $i \wedge i'$ gives $38° \ 44\frac{1}{2}$, that is, $141° \ 15\frac{1}{2}'$ for the inclination of the twinning-plane upon the prism i.

For the second case, the angle of $R \wedge R'' = 124° \ 2'$ gives $128° \ 53'$ for the angle between the prism and the twinning-plane, or $141° \ 7'$ if the twinning-plane is normal to the composition-plane. Again the angle of $i \wedge i'' = 102° \ 8'$ gives for the same angle $128° \ 56'$, or, on the other supposition, $141° \ 4'$. If we compare this angle (141°–142°) thus obtained with the inclination of the prism upon the successive planes of the zone between i and R having the general symbol $m\text{-}\frac{m}{m-1}$, we are surprised to find that it agrees quite closely with that which is required for $i \wedge 2\text{-}2$, viz. $142° \ 2'$. This plane 2-2, one of the most commonly occurring of all the various forms of quartz is thus *approximately the twinning-plane.* In the first case we obtained $141° \ 36'$ and $141° \ 15\frac{1}{2}$, and in the second case $141° \ 7'$, and $141° \ 4'$. There is here some discrepancy, but considering the relation of the crystals the correspondence is very remarkable.

The conclusion to which we arrive then, is this: that although the position of the quartz is unquestionably determined by the

calcite, nevertheless the resulting form possesses a remarkably high degree of symmetry, and approximates very closely to that which would be produced by a twinning parallel to the plane 2-2. The two adjacent crystals are united by the twinning-plane, and the two diagonally opposite by a plane normal to this, but the same law of twinning applies to both cases.

It can hardly be questioned that this fact, that by this method of grouping the form of the quartz approximates so closely to a form which might well exist independently, must be at least a partial reason why it is here placed in so remarkable a geometrical relation with calcite.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Size of Hydrogen Atoms.*—Annaheim has described a simple lecture experiment in which the coloring power of fuchsin and cyanin is made use of to illustrate the extraordinary divisibility of matter. To form an idea of the amount of coloring matter visible to the naked eye, he weighed out 0·0007 gram fuchsin ($C_{20}H_{19}N_3HCl$)—a fragment about half a millimeter in diameter—dissolved it in alcohol and diluted the solution to a liter. In each centimeter, therefore, there was contained 0·0000007 gram coloring matter; and yet, placed in a burette one centimeter in diameter, the color showed distinctly even from a distance. A single drop of this solution—of 35 to the cubic centimeter—in a test-tube placed on white paper showed a distinct red color. Hence it follows that the eye can perceive ·00000002 gram fuchsin. But if we assume that each drop contains only one molecule, and it cannot contain less, then, since the molecular weight of fuchsin is 337·5, the maximum weight of a hydrogen atom is $\frac{1}{337\cdot5}$ of 0·00000002 gram, or 0·000000000059 gram! The same experiment with cyanin ($C_{28}H_{35}N_2I$) whose molecular weight is 526, leads to a similar result. One milligram dissolved in a liter of alcohol, will give for each drop 0·0000000285 gram. From this, it appears that the weight of the hydrogen atom cannot exceed 0·000000000054 gram, a curiously close coincidence.—*Ber. Berl. Chem. Ges.*, ix, 1151, September, 1876. G. F. B.

2. *On the Atomic Weight of Selenium.*—Pettersson and Ekman have made an extended research on the atomic weight of selenium, analyzing for this purpose calcium, magnesium and silver selenates, ammonium-aluminum selenate, silver selenite, and selenous oxide, all of the greatest attainable purity. Silver selenite on ignition yields a beautiful crystalline crust of pure silver. Hence by weighing the salt, igniting and again weighing, the data for determining the atomic weight are obtained. As a mean of seven analyses, the atomic weight obtained was 79·01. By

reduction of selenous acid by sulphurous acid, collecting and drying the precipitate and weighing it, another determination was made. The mean of five determinations, which agree well with each other, is 79·08. The authors, believing the latter determination to have more weight, assign the atomic weight 79·08 to selenium, which they believe correct to the first decimal place.—*Ber. Berl. Chem. Ges.*, ix, 1210, September, 1876. G. F. B.

3. *An improved Nitrogen-measuring Tube.*—ZULKOWSKY has improved the apparatus for measuring nitrogen by volume, which was proposed by Dumas. It consists of two tubes, 1·8 cm. diameter, and 58 cm. long, one of which is closed at the top, while both are drawn down at bottom so as to slip a rubber tube over the ends. The closed tube is graduated, and it, as well as the other tube, has a small lateral tube attached 44 cm. from the top, the one on the closed or measuring tube for connecting the apparatus with the combustion tube, the other furnished with a quetschhahn, for drawing off the liquid within. The two tubes are held parallel and upright and form a U tube. By turning the measuring tube down it may be filled with a potash solution. The combustion is proceeded with as usual, carbon dioxide evolved from hydro-sodium carbonate being used first to drive out the air. As the bubbles rise through the potassium hydrate, they are more and more perfectly absorbed. When this process is finished the substance is heated and the nitrogen is allowed to come over. Its temperature is noted, and, after making the level of the liquid the same in both tubes, its volume is read and reduced to the normal pressure and temperature. Analytical results obtained with it are given which are exceedingly accurate.—*Liebig's Ann.*, clxxxii, 296, September, 1876. G. F. B.

4. *On the Physical properties of Gallium.*—BOISBAUDRAN, having prepared a decigram of very nearly pure gallium, has made some careful observations on its physical properties. Its fusing point is about 29·5°, so that the heat of the hand liquefies it. When liquid, it exhibits the phenomena of surfusion to a remarkable degree. It has remained liquid for more than a month, the globule being frequently broken and reunited again by a steel blade, in a room the temperature of which often fell below the freezing point. Contact with a bit of solid gallium however, solidified it at once. Liquid gallium is very mobile, appears covered with a pellicle when exposed to the air, and adheres strongly to glass. Only a few degrees below its fusing point, the metal is hard and remarkably tenacious; but it may be cut with a knife as aluminum may. It crystallizes with facility, crystal facets being developed by treatment with hydrochloric acid. It does not oxidize at a red heat except upon the surface and it does not volatilize. Its spark spectrum gives the two well-known bright lines of wave length 417 and 403·1; its flame spectrum only the 417 line and this difficultly. Its density, approximately, is 4·7; thus placing it, like its other physical properties, between aluminum and indium. Its atomic weight places it there, probably, also.—*J. Phys.*, v, 277, September, 1876. G. F. B.

5. *New Vapor-density method for Substances of high Boiling-points.*—The labor consequent upon the determination of a vapor density in the case of a substance of high boiling point by the method of Deville and Troost, has led VICTOR MEYER to contrive a new method which is simple and easily applied, using no more material than the method of Hofmann and yet making determinations up to the boiling point of sulphur, 444·2°. In place of mercury, Wood's fusible metal, fusing at 70° C. is used. The principle involved consists in volatilizing a small but accurately weighed quantity of the substance in a vessel previously completely filled with the fusible metal, and then determining the volume of the vapor by heating in sulphur vapor and measuring the quantity of metal which has overflowed. The vessel employed is a bulb of about 25 c. c. capacity having a fine point at top and a tube 6 to 7 mm. diameter and 6·7 centimeters long issuing from the bottom and bent upward to just above the point. The author has determined as data, the specific gravity of the alloy at 444°, and its expansion coefficient between 98° and 444°; one gram at 98° increases 0·1092 c. c. at 444°. The substance is placed in a small tube, which it must completely fill, and is introduced into the bulb which is then completely filled with the metal, care being taken to exclude air-bubbles. After heating to the temperature of boiling water, the excess of metal on the tube is removed and the whole is weighed to decigrams. The bulb is then fastened to a wire, and the whole is plunged in the vapor of boiling sulphur till the temperature is uniform. It is then removed, allowed to cool partially and weighed. The difference in weight is the amount of overflow. Knowing the expansion-coefficient, its volume is easily calculated and reduced. All the data are now known, and in calculating the density the author uses the formula

$$D = \frac{S \cdot 14146000}{(a-0{\cdot}036b)\ (P+\tfrac{3}{8}p)},$$

in which S is the weight of the substance used, *a* the weight of the metal used, *b* that which overflowed, P the barometric height, *p* the difference of level within and without. The density of diphenyl thus obtained is 5·33; cal. 5·32. Of anthracene 6·24; cal. 6·15. Of triphenylamine 8·49; cal. 8·48. Of anthraquinone 7·22; cal. 7·19. Of paradibrombenzene 8·14; cal. 8·15.—*Ber. Berl. Chem. Ges.*, ix, 1216, September, 1876. G. F. B.

6. *On Glycero-phosphoric acid from Brain Tissue.*—THUDICHUM and KINGZETT have described some of the salts of glycero-phosphoric acid obtained from kephalin, a substance prepared by the former from brain tissue. When boiled with baryta water, barium salts of certain fatty acids, barium glycero-phosphate, and one or two nitrogenous bases result. The lead, calcium and barium salts of glycero-phosphoric acid are described. A singular compound of the barium salt, called an alcoholo-hydrate, was obtained by precipitating it by alcohol, which contains probably three molecules of alcohol and six of water united to one of acid

glycero-phosphate. The authors give certain theoretical views concerning the kephalins, myelins and lecithins in the brain, all of which yield this acid.—*J. Chem. Soc.*, xxx, 20, July, 1876.

G. F. B.

7. *Chemistry: General, Medical, and Pharmaceutical, including the Chemistry of the U. S. Pharmacopœias. A manual of the general principles of the science, and their applications in medicine and pharmacy;* by JOHN ATTFIELD, Ph.D., F.C.S., etc. Seventh edition. Revised from the Sixth (English) edition by the Author. 668 pp. 12mo. Philadelphia, 1876. (H. C. Lea.)—Dr. Attfield's book has in nine years appeared in seven successive editions, of which the present has been adapted by the author expressly to the convenience of American students in medical chemistry. It is an excellent book in many respects, and evidently meets the wants of the class of students for whom it was prepared. The modern nomenclature and philosophy of chemistry and the metric system are used in the work. B. S.

8. *A Systematic Hand-book of Volumetric Analysis, etc.;* by FRANCIS SUTTON, F.C.S., etc. Third edition. 438 pp. 8vo. Philadelphia, 1876. (Lindsay and Blakiston.)—The former editions of Mr. Sutton's excellent hand-book have long been in the hands of chemists. The second edition has for some time been out of print, however, and therefore the third edition is the more acceptable to working chemists who will find in it a careful digest of this department of chemical literature brought down to September, 1876. It bears marks of careful revision throughout. The sections on the analyses of potable waters and sewage have been completely revised and much enlarged by Mr. W. Thorp, long connected with the Pollution of Rivers Commission, as Chief Chemical Assistant under Drs. Frankland and Armstrong. The methods of analysis of potable waters introduced by these chemists are in this volume carefully collated from the original sources and presented in clear and exact statements. The chapters on gas analysis by Prof. McLeod have also been revised and extended. Under this head the author would have added to the value of his hand-book by introducing the eudiometrical apparatus described by Mr. C. W. Hinman in this Journal for September, 1874, (vol. viii, p. 182), which combines the good points of Russell and Williamson's, Doyère's, and Gibbs' apparatus with others of his own in a very compact form, giving accurate results with a very important saving of time and labor and the great convenience of enabling the chemists to conduct the analyses in any ordinary room. This book well deserves the highest commendation for its fullness, accuracy and systematic arrangement of the entire subject. It is a pleasure for once to see an American edition of an English science-manual escape the mutilation too frequently committed in the so-called "reprints from the last London edition."

B. S.

9. *Chemia Coartata, or the Key to Modern Chemistry;* by A. H. KOLLMYER, A.M., M.D., etc. iii pp. 12mo. Philadelphia. (Lindsay and Blakiston).—This is an attempt to present some of

the leading facts of chemistry in a tabular form. The facts are arranged in classified groups under the heads, Substance, Synonyms, History, Obtained form, Equations, Properties and Tests. "The main object of the author has been to compress into as small a space as possible everything connected with the study that deserves attention, and to give no more explanatory matter than is actually required to render each subject perfectly intelligible." It is evident from this statement that the author attempts too much for the beginner and accomplishes too little for the proficient student.

B. S.

10. *Lissajous' Curves.*—M. Mercadier has introduced some improvements in the apparatus for producing these curves. Two large tuning forks are maintained in vibration by an electric current circulating around a magnet placed between the prongs. The pitch is regulated approximately by two weights of five or six hundred grams and a variation of an entire octave is thus attained. The main improvement is in the apparatus for varying the pitch by small amounts without stopping the forks. To one of the prongs is attached a small split nut through which a screw passes with a loaded head. The latter instead of being round has four projecting arms by means of which it may be turned with the finger or a small hammer. The distance of the center of gravity of the screw from the end of the fork is thus altered and with it the rapidity of the vibration. It is easy to see that the period of vibration increases with the amplitude, and although this change is very small, yet the optical method is so sensitive that it shows it clearly.—*Journal de Physique*, v, 309. E. C. P.

11. *Mechanical Equivalent of Heat.*—The committee of the British Association appointed to determine this constant, report progress as follows: Dr. Joule has been engaged in further measurements by means of the friction of water, and as the average result of sixty experiments gives 772·2 in British gravitation units at Manchester. The greatest deviation from the above average is $\frac{1}{200}$. Experiments have yet to be made on the capacity for heat of the calorimeter, the provisional computation being based on the experiments of Regnault. The greatest possible error from this source is probably $\frac{1}{300}$ and that from the incorrect boiling point of the thermometers $\frac{1}{400}$ The maximum value of these two corrections might amount to 4·5 in the above values. The experiments of Hirn on the friction of water have given him 786, but the average of his results from the friction, boring and crushing of metals gives 776. Assuming that the above experiments and those made by Dr. Joule for the committee on Standards of Electrical Resistance are to be relied on, the unit issued by it would appear to have a resistance one-fortieth too small. Inasmuch as the locality in which the experiments for that unit were conducted was open to objection, it appears desirable that they should be conducted under more favorable circumstances.—*Nature*, xiv, 476.

E. C. P.

12. *Ohm's Law.*—Prof. Maxwell presented to the British Association at their last meeting the Report of the Committee for Testing Experimentally the Exactness of Ohm's Law. The prin-

cipal difficulty arises from the fact that the current generates heat, so that it is extremely difficult to keep the temperature constant with different currents. Since the resistance is the same whichever way the current passes, the resistance, if not constant, must depend upon even powers of the intensity of the current through each element of the conductor. Hence if we cause a current to pass in succession through two conductors of different sections, the deviations from Ohm's law will be greater in the conductor of smaller section, and if the resistances are equal for small currents they will be no longer equal for large currents. The first test was by means of five coils each of thirty ohms resistance, and two others to complete the bridge. A difference of over four-millionths in the relative resistance of any two of these coils proved to be measurable. According to Ohm's law, if either four of these were connected two and two, the resistance should be equal to that of the fifth coil. By mercury cups these were connected in such a way that each in turn could be compared with the other four. The results showed a small deviation from the law, probably due to irregularity in the conducting power of the connections since it was not confirmed in the more searching tests afterward applied.

A second method was next adopted in which weak and strong currents were alternately passed through two wires of nearly equal resistance but one short and fine the other coarse and long. The currents were changed thirty, and sometimes sixty times a second, so that the wire could not sensibly change in temperature in the interval. Since the current has far greater intensity in the fine than in the coarse wire the deviation should be correspondingly great. Combining these resistances with two coarse wires in a Wheatstone's bridge, if equilibrium occurred it must be due to either one of two causes. Either Ohm's law is true and there is no difference in the effect of the two currents, or the apparent equilibrium must arise from a succession of equal and alternate currents those in one direction due to the stout wire, those in the other to the fine wire. The latter case is easily tested by reversing the direction of the weaker current when its effect should add to that of the other. Currents are employed in some cases so powerful as to heat the finer wire to redness, but whenever the action was steady the reversal of the weaker current gave no result. Mr. Chrystal, by whom the experiments were performed, has put his result in the following form: If a conductor of iron, platinum or German silver of one square centimeter in section has a resistance of one ohm for infinitely small currents, its resistance when acted on by an electromotive force of one volt (provided its temperature is kept the same) is not altered by so much as the millionth of the millionth part.

It is seldom, if ever, that so searching a test has been applied to a law which was originally established by experiment, and which must still be considered a purely empirical law, as it has not hitherto been deduced from the fundamental principles of dynamics.

But the mode in which it has borne this test not only warrants our entire reliance on its accuracy within the limits of ordinary experimental work, but encourages us to believe that the simplicity of an empirical law may sometimes be an argument for its exactness, even when we are not able to show that the law is a consequence of elementary dynamical principles.—*Nature*, xiv, 452. E. C. P.

13. *Protection of Buildings from Lightning.*—Prof. MAXWELL suggests another system of protecting buildings quite unlike that in common use. Attention is generally especially devoted to the two ends of the conductor, to secure an elevated and pointed terminal above and a good connection with moist earth below. This system seems calculated rather for the benefit of the surrounding country and for the relief of clouds laboring under an accumulation of electricity, than for the protection of the building on which the conductor is erected. What we really wish is to prevent the possibility of an electric discharge taking place within a certain region, say in the inside of a gunpowder manufactory. An electric discharge cannot occur between two bodies unless the difference in their potentials is sufficiently great compared with the distance between them. This may be avoided by connecting all these bodies by good conductors as wire ropes. But this is not necessary if the exterior is covered with a good conductor. Thus, if the roof, walls and ground floor are covered with thick sheet-copper, no electrical effect could be produced inside by a thunder storm. No earth connection would be necessary and the building might even be insulated by a layer of asphalte. Any long conductor, as the gas or water pipes, should be connected with the sheet copper. Accordingly a telegraph wire should not pass inside the building, since this connection would render it useless. An entire covering is by no means necessary. A network formed by carrying a stout copper wire around the foundation, up each of the corners and gables and along the ridges would probably be sufficient for any thunderstorm in this climate. If there are any gas or water pipes, they should be connected with the wires, but if there are no such metallic connections with distant points, it is not necessary to take any pains to facilitate the escape of the electricity into the earth.—*Nature*, xiv, 479. E. C. P.

14. *On the Tidal Retardation Argument for the Age of the Earth.*—Mr. JAMES CROLL, LL.D., F.R.S., of the Geological Survey, read a paper "On the Tidal Retardation Argument for the Age of the Earth." Many years ago Sir William Thomson demonstrated from physical considerations that the views which then prevailed in regard to geological time and the age of our globe were perfectly erroneous. His two main arguments, as are well known, were—first, that based on the sun's possible age; and secondly, that based on the secular cooling of the earth. More recently he has advanced a third argument (Trans. Geol. Soc of Glasgow, vol. iii, p. 1), based on tidal retardation. It is well known that owing to tidal retardation the rate of the earth's rotation is slowly diminishing, and it is, therefore, evident that if we

go back for many millions of years we reach a period when the earth must have been rotating much faster than now. Sir William's argument is, that had the earth solidified several hundred millions of years ago the flattening at the poles and the bulging at the equator would have been much greater than we find them to be. Therefore, because the earth is so little flattened it must have been rotating, when it became solid, at very nearly the same rate as at present. And as the rate of rotation is becoming slower and slower, it cannot be so many millions of years back since solidification took place. A few years ago I ventured to point out (*Nature*, Aug. 21st, 1871; Climate and Time, p. 335,) what appeared to be a very obvious objection to the argument, and as the validity of the objection, so far as I am aware, has never been questioned, I have been induced to believe that the argument referred to had been abandoned. But I find that Professor Tait in his work on "Recent Advances in Physical Science," restates the argument as perfectly conclusive, and makes no reference whatever to my objection. As the subject is one of very considerable importance, I may be permitted to direct attention to the objection in question, which briefly is as follows:

It has been proved by a method pointed out a few years ago (Philosophical Magazine, May, 1868, pp. 378–384, February, 1867, p. 180; Climate and Time, Chap. xx; Transactions of Geological Society of Glasgow, vol. iii, p. 153), and which is now generally admitted to be reliable, that the rocky surface of our globe is being lowered, on an average, by subaerial denudation at the rate of about one foot in 6,000 years. It follows as a consequence from the loss of centrifugal force resulting from the retardation of the earth's rotation, occasioned by the friction of the tidal-wave, that the sea-level must be slowly sinking at the equator, and rising at the poles. This, of course, tends to protect the polar regions, and expose equatorial regions to subaerial denudation. Now, it is perfectly obvious that, unless the sea-level at the equator has, in consequence of tidal retardation, been sinking during past ages at a greater rate than one foot in 6,000 years, it is physically impossible that the form of our globe could have been very much different from what it is at present, whatever may have been its form when it consolidated; because subaerial denudation would have lowered the equator as rapidly as the sea sank. But in equatorial regions the rate of denudation is, no doubt, much greater than in the temperate regions. It has been shown in the papers above referred to that the rate at which a country is being lowered by subaerial denudation, is mainly determined, not so much by the character of its rocks, as by the sedimentary carrying power of its river systems. Consequently, other things being equal, the greater the rain-fall the greater will be the rate of denudation. We know that the basin of the Ganges for example is being lowered by denudation at the rate of about one foot in 2,300 years, and this is probably not very far from the average rate at which the equatorial regions are being denuded. It is therefore evident that subaerial denudation is lowering the equator as

rapidly as the sea level is sinking from loss of rotation, and that consequently we cannot infer from the present form of our globe what was its form when it solidified. In as far as tidal retardation can show to the contrary its form may have been as oblate as that of the planet Jupiter when solidification took place.

There is another circumstance which must be taken into account. The lowering of the equator by the transference of materials from the equator to the higher latitudes must tend to increase the rate of rotation, or, more properly, it must tend to lessen the rate of tidal retardation.

15. *Sound*, by JOHN TYNDALL. 448 pp. 8vo. Third edition, revised and enlarged. New York. 1876. (D. Appleton & Co.)—The Preface to the new edition of this valuable work opens with the statement of the author that in preparing this new edition of his work he has amended, as far as possible, its defects of style and matter, and paid at the same time respectful attention to the criticisms and suggestions which the former editions called forth. The most important new matter introduced is an account of the author's investigations on the acoustic transparency of the atmosphere in relation to Fog-signaling. The preface contains an account of work done in the same line in America, and especially by Prof. Henry, after which follow arguments against Prof. Henry's explanation of the observed phenomena. The distinguished author repeats in his preface his former remarks on the "injurious influence still exercised by authority in science," that it is "not only injurious but deadly when it cows the intellect;" when if any one's intellect has been thus cowed in this free age, no one is to be blamed but himself.

16. *Entwickelung der theoretischen Ansichten über die gepaarten Schwefelverbindungen von* GEORGE A. SMYTH (of Amherst, Mass.) 122 pp. 8vo. Berlin. 1876.

II. GEOLOGY AND MINERALOGY.

1. *Report on the Geological Map of Massachusetts, prepared by* W. O. CROSBY, Assistant in the Laboratory of the Boston Society of Natural History. 52 pp. 8vo. Boston, 1876.—The map here referred to is one colored for the Centennial Exposition at Philadelphia. Mr. Crosby lays down the distribution of Norian, Huronian, Mont-Alban, and Paleozoic areas in the State, gives an account of the rocks, characterizing them, stating briefly their kinds and their supposed stratigraphical relations. Of the rocks of the State, the remark is made at the outset, that they "are mainly crystallines, which are believed to belong wholly to the Eozoic [Archæan] era;" but no satisfactory evidence on this question of age is brought forward except that with regard to the formation underlying unconformably the Primordial of Braintree. The fossiliferous limestone of Bernardston, containing large crinoidal stems, and referred by Hall, Billings and others to the Helderberg formation (lower or upper), and which underlies mica slate and quartzyte, seems to be included by the author with the Mont-

Alban, the statement being made that the argillite of Bernardston is of this age; if not so intended, this most interesting formation is left unnoticed. Of the age of the limestone and associated rocks in Berkshire, Mr. Crosby says: "it seems probable that it will ultimately prove to be, as an increasing number of geologists are inclined even now to regard it, older than the Primordial." Such a conclusion is at variance with the fact of the existence of Lower Silurian fossils at some Vermont localities in the limestone. The pamphlet closes with an account of the Geology of the Nashua Valley, by L. S. Burbank.

2. *Geological Survey of Indiana; Seventh Annual Report on the Surveys made during the year* 1875, E. T. Cox, State Geologist. 302 pp. 8vo.—This Report treats of the special geology of Vigo and Huntington counties, by Mr. Cox; of Riply and Jennings counties, by W. W. Borden; of Orange, by M. N. Elrod and E. S. McIntire; of Vanderburg, Owen and Montgomery counties, and portions of Clay and Putnam counties, by J. Collett; and contains also a report on the depth and temperature of the lakes of Northern Indiana, by G. M. Levette, and another on the Flora of the Wabash Valley, by J. Schenck, M.D., and on Fossil marine plants of the Carboniferous, by L. Lesquereux. The volume commences with a General Report by the head of the Survey, which includes a review of the principal observations of the year, together with information on the Coals of the State, with the results of numerous analyses, on the distribution of the millstone grit and on its whet-stone bed in Orange Co., with a list of the fossil plants in this bed, as furnished by Prof. Lesquereux.

Mr. Levette's survey of the Lakes states that the ancient shores of many of the lakes afford a chalky material, which is nearly pure carbonate of calcium (with 3 or 4 per cent of magnesia), the beds of which are in some places 20 or 30 feet thick. It affords no evidence of organic origin, and hence is stated to be probably a chemical deposit. An *artesian boring* at Fort Wayne has reached a depth of 3,000 feet; the first 88 feet were of drift; and then it entered a Niagara limestone, and continued through limestone and calcareous shale to 2,500 feet; thence, through soft calcareous rock to its present bottom in the Lower Silurian. The temperature at 90, 100, 1,000, 1,500 and 2,635 feet, registered by the thermometer was 51½° F. Another well at Wabash commenced in the Niagara limestone and was continued in limestone and calcareous shale to a depth of 2,270 feet, without getting a flow of water. At 100, 500, 1,000, and 2,270 feet the temperature of the water obtained was 50½° F. The thermometer was one made for the purpose by James Green of New York. Mr. Cox says that "The inference to be drawn from the uniform temperature of these wells is that they are filled with water that comes from an upper stratum." In another well 1,923⅛ feet deep at Terre Haute, penetrating the Coal measures and Devonian, and stopping, it is believed, in the Niagara, the temperature obtained throughout was 81° F.; and this is referred to waters from the lower part of the well filling it.

3. *Geological Map of Scotland*, by ARCHIBALD GEIKIE, Director of the Geological Survey of Scotland. Edinburgh. (W. & A. K. Johnston, Geographers and Engravers to the Queen).—Professor Geikie has contributed much by his own labors to the knowledge of Scottish geology, and thereby, aided also by the labors of others on the survey and of independent investigations, he has been enabled to make great improvements in preparing this new edition of the map. It is well colored, and presents to the eye illustrations of various problems of great interest to general geology. It is of convenient portable size, measuring about one foot ten inches by two feet ten.

4. *Huronian of Canada.* Letter from Mr. A. R. C. SELWYN, Director of the Geological Survey of Canada, to J. D. Dana, dated Montreal, October 28th, 1876.—Referring to Article XXXVI in the October number of your Journal, it seems to me that Mr. Bradley has quite misunderstood what I wrote him respecting the so-called Huronian Series of Canada. I am not aware that I ever mentioned Sir William Logan's name to Mr. Bradley, in the matter; and certainly if Sir William held the views attributed to him, he never informed me of the fact. When Mr. Bradley sent me a copy of his map, in acknowledging the receipt of it I remarked that I could not agree in the propriety of including the whole of the Huronian Series in the Silurian System, though I saw no reason for supposing it to be older than the Cambrian—Harlech and Longmynd rocks—of the British Survey, which are supposed to occupy a position between the Primordial and the Laurentian, which is also the position assigned to the Huronian series in America. I informed Mr. Bradley that the Mistassinni Lake Huronian band was, in some part of its course, from 150 to 200 miles wide, (not 300 miles as stated), and that in mineral character part of it very closely resembled the altered Quebec group of Canada, notably in the chromiferous serpentine, magnetite and dolomite. If, however, it is an established fact that in Minnesota and Wisconsin the same Huronian rocks are unconformably covered by the Potsdam sandstone it becomes certain, whatever their mineralogical resemblances may be, that they cannot belong to the Quebec group, and we have not, so far as I know at present, any evidence which would warrant us in classing them with the Silurian.

5. *Geological Survey of Michigan. Fossil Corals, by* Dr. C. ROMINGER, *State Geologist.* 154 pp. 8vo, with 55 plates.—An "advance copy, unrevised by the author," has been received, and it gives us great pleasure to announce the appearance of a work that will so largely meet the necessities of American paleontological science in the department of Fossil Corals. The illustrations are albertypes, and beautiful specimens of the art, being among the best from the engraving office of Julius Bien of New York. The science of the country owes much to the Geological Board of the State of Michigan, that they authorized the preparation and publication of so complete and well-illustrated a Report on this hitherto much neglected branch of American Paleontology.

6. *Memoirs of the Geological Survey of India. Palæontologica Indica.*—Published by order of the Governor General of India in Council, under the direction of Thomas Oldham, LL.D., Superintendent of the Geological Survey of India. Vol. i, Parts 2, 3 and 4 (1875), contain the continuation of the memoir on the Jurassic Ammonitidæ of Kutch, by William Waagen, Ph.D. They include plates 5 to 60, and finish the volume.

The *Memoirs of the Survey* in octavo, vol. xi, part 2 (226 pages), contain, a paper of 226 pages by Mr. Wynne, on the *Trans-Indus Salt region*, Kohat District, which is illustrated by several fine plates, showing the displaced and folded character of the rocks. The folds, which are often of great complexity, include the Nummulitic and other Tertiary beds. The Rock Salt belongs to the lower part of the Nummulitic strata, and is referred to the early Eocene. In some places, and especially near Bahádur Khél, the salt forms high detached hills, cliffs, and naked exposures for a distance of four miles, with a width exceeding a quarter of a mile; and to the eastward for four miles, there are large crater-like holes, proving its presence now or formerly beneath the surface. Throughout the district it frequently appears in precipitous outcrops within the elliptical boundaries of the Nummulitic limestone. The salt is, for the most part, remarkably pure, without admixture with potash salts. The maximum thickness of the salt rock is not less than 1,230 feet. It is associated with gypsum, and to the eastward is somewhat bituminous at top. The underlying strata are not known; and the absence of fossils from the salt beds leave some doubt as to its precise age. A large colored geological map accompanies the memoir.

The *Records of the Geological Survey*, vol. ix, part 1, 1876, contain a brief Annual Report, together with an account of the Geology of Sind, by Wm. T. Blanford, the rocks of which, thus far observed, range from the Infra-nummulitic, supposed to be Lower Eocene to the Pliocene and more recent.

7. *Detritus of Rivers.* — The Liverpool Geological Society held its first annual meeting of the session on the 10th instant, when the retiring president, Mr. T. Mellard Reade, C.E., F.G.S., delivered his annual address. The subject was an interesting one, being a calculation of the amount of solid matter removed annually from the surface of England and Wales in solution, in rain, or rather river water. The result of the calculations, which were of an elaborate nature, founded upon the analysis of water given by the Rivers' Pollution Commission in their Sixth Report, and the rainfall chart prepared by Mr. Symons, showed that it would take 13,000 years to remove, in this manner, one foot in depth of solid matter over the entire surface of England and Wales. This calculation was compared with others prepared by Mr. Reade, of the soluble denudation of the great river basins of Europe, viz: the Danube, the Rhine, and the Rhone. As throwing light upon the age of sedimentary deposits, the calculations taken, together with the amount of matter annually brought down in river water

in suspension in the form of mud, are extremely interesting, and Mr. Reade deduced from them that the minimum amount of time which must have elapsed since the first sedimentary rocks we know of were laid down is, in round numbers, 500 millions of years, thus supporting the views of Lyell, Hutton, and other great geologists, as to the immense age of the world.—*Nature*, Oct. 26.

8. *Mallet's Theory of Volcanic Energy.*—The paper of Prof. Mallet upon volcanic energy, which was translated into German by Prof. A. von Lasaulx, has been somewhat severely criticized in the Göttingen Gelehrte Anzeige by O. Lang. This criticism has recently been fully answered by Prof. Lasaulx. He gives a satisfactory demonstration of the mathematical formula referred to $\left(T = \frac{P\rho}{2}\right)$, that by which Mallet proves that a crushing of the materials of the earth's crust must take place, and shows that it is mathematically complete. Moreover, he convicts Mr. Lang of a total misunderstanding of the question involved, and shows that he himself is alone responsible for the difficulties which he suggests.

9. *Geological reunion at the Paris Exposition in* 1878.—The American Association for the Advancement of Science, at its session on the 25th of August last, unanimously adopted the following resolution:—

Resolved, That a Committee of the Association be appointed by the Chair to consider the propriety of holding an International Congress of Geologists at Paris, during the International Exhibition in 1878, for the purpose of getting together comparative collections, maps and sections, and for the settling of many obscure points relating to geological classification and nomenclature. And that to this Committee be added our guests, Prof. T. H. Huxley of England, Dr. Otto Torell of Sweden, and Dr. E. H. von Baumhauer of the Netherlands, who shall be requested to open negotiations in Europe looking to a full representation of European geologists at the proposed Congress. The said Committee to consist of Prof. William B. Rogers, Messrs. James Hall, J. W. Dawson, J. S. Newberry, T. Sterry Hunt, C. H. Hitchcock and R. Pumpelly, in behalf of the Association, with the addition of Prof. T. H. Huxley, Dr. Otto Torell and Dr. E. H. von Baumhauer.

On the same day, at a meeting of the Committee, Prof. James Hall was elected Chairman, and Dr. T. Sterry Hunt, Secretary. A circular has since been issued, which is to appear in English, French and German, and to be distributed to geologists throughout the world, asking their coöperation in this great work of an International Geological Exhibition and an International Geological Congress to be held at Paris in 1878; the precise date of the Congress to be subsequently fixed.

This circular recommends with reference to the objects of the Congress, that the Geological department of the Exposition shall embrace: (1) Collections of rocks, illustrating all points of lithological and geological interest; (2) of fossils, and especially of the Primordial or Cambrian; and (3) of geological maps and sections.

10. ***Recent Discoveries of the Brazilian Geological Commission;*** by THEO. B. COMSTOCK, Assistant Professor in charge of Geological Department, Cornell University.—The Rio Curupatúba enters the Amazonas from the north at a distance of four hundred miles from the Atlantic coast. A few miles above the confluence of these rivers, on the left bank of the former, is situated the villa of Monte Alegre. From this point, in 1870, while acting as an assistant on the first Morgan expedition from Cornell University, the writer made a trip northwestward across the country over the trail leading to the hamlet of Ereré.* Messrs. Herbert H. Smith and Phineas P. Staunton were of the party. Shortly after crossing the Igarapé de Ereré, a small river which communicates with the Curupatúba through the lower portion of the Igarapé do Paitúna, we discovered an exposure of Devonian shales yielding a few fossils, afterward identified by Mr. Richard Rathbun. He found them to be related to species characteristic of the Hamilton Period in New York State, one being only a variety of *Discina Lodensis* Hall, while the others were new species of the genus *Lingula*.† In his review of the geology of this region, Professor Hartt remarks:‡ "The great repository of fossils is the sandstone, which . . . . appears to form bands a few inches in thickness, interstratified with the shales in their upper part. [N. B.—These shales are probably not the equivalents of those previously mentioned, for they are exposed two miles north of the little village of Ereré.—T. B. C.] . . . . ." "The fossils most abundant in the sandstone are the Brachiopoda, which are represented by twenty species belonging to the following genera: *Terebratula*, *Vitulina*, *Tropidoleptus*, *Spirifera*, *Cyrtina*(?), *Retzia*, *Streptorhynchus*, *Chonetes*, *Orthis*, *Rhynchonella* and *Lingula*, all of which are described in the paper of Mr. Rathbun."

The structural geology of the Ereré-Monte Alegre district was studied with considerable care by Professor Hartt and his assistants on the first Morgan expedition, and further details were determined by himself and Mr. O. A. Derby in the following year (1871). They were unable, however, wholly to unravel some of the more difficult problems presented in that region, for which reason Messrs. Derby, Smith and Freitas, of the Brazilian Geological Commission, have spent the past few months in a thorough survey of the whole area. The importance of the results obtained by them, as reported in a recent letter from Mr. Derby, will be better understood after a brief review of the general physiognomy of the district under consideration.

The villa of Monte Alegre (upper town) is perched upon the top of a comparatively level block of horizontal Tertiary beds,

* See Preliminary Report on the Geology and Physical Geography of the Ereré-Monte Alegre District, by Professor Ch. Fred. Hartt, in charge of the expedition, in Bulletin of the Buffalo Soc. Nat. Sci., January, 1874.

† *L. Graçana* Rathbun, and *L. Stauntoniana* Rathbun, figured and described in his paper "On the Devonian Brachiopoda of Ereré, Province of Pará, Brazil, in Bull. Buffalo Soc. Nat. Sci., January, 1874, p. 259.

‡ Ibid., p. 212.

extending in a curved line to the north and the east. To the southward stretch the broad alluvial Amazonian plains, across which the Curupatúba has cut its way, and through a part of which the lower portion of the Igarapés of Ereré and Paitúna are now flowing. The upper portion of the Igarapé de Ereré and its little tributaries together drain the nearly square Devonian floor, at the southern side of which is situated the Indian village of Ereré. The rocks over the last mentioned area are horizontal or but little inclined, but the square space is partially enclosed by bold *serras* of more complicated structure and of other formations. A series of ridges extending across the southern limit of the plain comprises the serras of Ereré; Aroxi and Aracuré, the western edge is bounded by ranges of low hills; the serra of Tanajurí occupies the eastern end of a row of ridges along the northern side, and the Monte Alegre plateau completes the enclosure. The serra do Paitúna lies off by itself a few miles beyond the southern boundary of the square.

The table-topped hills between Prainha and Almeirim (Serras de Parú), noticed in nearly every account of Amazonian travel, were never examined carefully until Professor Hartt visited them in 1871.* They lie much farther to the east, down the Amazonas from Monte Alegre, and have generally been regarded by travelers as members of the same system of *serras* as the ridges of Ereré, Paitúna and Tanajurí. This view was shown to be erroneous by Hartt,† who examined the westernmost one of this series, known as the serra Parauaquára, and found it to be made up of horizontal strata probably of Tertiary age.

Messrs. Derby and Smith, with Senhor Freitas have now succeeded in resolving the equivalents of the formations outcropping over the Ereré-Tanajurí district, with results of great interest to science. They have discovered a few localities rich in fossils, such being quite uncommon in this tropical region where exposures are few and the rocks very much weathered. The serras, in which the rocks are much contorted, are composed largely of Cretaceous beds extending downward into the upper Paleozoic formations, Carboniferous and Devonian. North of Ereré, they discovered 1000 feet or more of Lower Devonian rocks, underlying those found by Mr. Smith and the writer in 1870. These new beds are mainly *parachronous*‡ with the Oriskany sandstone of North America. Mr. Derby writes that he has obtained from this horizon "seventy-five species, including several characteristic Oriskany species, mixed with true Devonian forms. The Oriskany here is certainly Devonian." This discovery seems very significant in its bearing upon certain theories in connection with "cycles of deposition." An apparent conflict in geognostical and paleontological

* Von Martius, in fact, was the only previous visitor to the serras. He reported (*Reise in Brasilien, IIIer Theil*, *S.* 1326), upon the botany of one of the Serras de Almeirim, but barely touches its geology.

† Bull. Buff. Soc. N. S., ibid., p. 228, *et seq.*

‡ The term *parachronous* was suggested by the writer (Reconn. N. W. Wyoming, etc., Jones, 1874, p. 143) as convenient to apply to beds of the same *relative* age, when true *synchronism* is uncertain.

records is thus harmonized, as it appears. The same number of species is reported from the Upper Devonian of the Ereré district, and the Carboniferous beds have yielded a similar number to Mr. H. H. Smith, among which there are probably some entirely new forms. The latter formation appears to extend widely over South America, as elsewhere. The fossils identified by Mr. Derby, which were collected on the Morgan expeditions, came from outcrops in the vicinity of Itaitúba, on the Rio Tapajos,* and these were regarded by him as closely related to the Bolivian Carboniferous fauna and to other beds of similar age (Coal measures) in both North and South America and in Europe.† The Cretaceous beds of the serras have afforded many fossils, in places, but no details are furnished by the members of the Imperial Survey.

Professor Hartt, at latest account, was engaged in a personal exploration of the Coal-Measure area in the southern province of Santa Catharina, where characteristic plant-fossils and workable beds of coal are known to exist.‡ The occurrence of coal in the valley of the Amazonas has been suspected; there is probably no region in the world where it could be more advantageously employed, but as yet no exposure of valuable beds has been reported.

11. New Minerals. *Mottramite, Roscoelite.*—Prof. H. E. Roscoe has recently described a new vanadium mineral, under the name of *Mottramite.* It occurs as a crystalline incrustation on the Keuper sandstone at Alderley Edge, and at Mottram St. Andrew's, Cheshire, England. The incrustation is usually thin, but sometimes 3 or 4 mm. in thickness. Occasionally in minute crystals of a black velvety appearance in the mass, but by transmitted light yellow. Also compact, opaque, and of a purplish brown color. Luster resinous. Streak yellow. H.=3; G.=5·894. The mean of two analyses gave V_2O_5 17·14, PbO 50·97, CuO 19·10, (Fe, Zn, Mn)O 2·52, CaO 2·13, MgO 0·26, H_2O 3·63, moisture 0·22, silica 1·06=97.03. The formula is written $(PbCu)_3V_2O_8+2H_2(PbCu)O_2$ analogous to erinite and dihydrite.

Prof. Roscoe has also examined the *roscoelite*, named by Dr. Blake, and since described by Dr. Genth (see this Journal, III, xii, 31, 32). The formula to which his analysis leads is as follows:—$2AlV_2O_8+K_4Si_9O_{20}+aq.$; this is quite a different result from that obtained by Dr. Genth.—*Proc. Roy. Soc.*, June 15, 1876.

12. *The "Mexican Onyx."*—Prof. Marianor Bacena, of the Mexican Commission to the Centennial Exposition, has recently published an account of the occurrence and chemical character of the rocks called *Mexican onyx.* The principal deposits are located near the town of Tecalli, in the State of Puebla. It is essentially a carbonate of calcium, containing small quantities of the oxides

* A tributary of the Amazonas, entering the latter from the southwest at Santarem, not many miles above Monte Alegre.

† See paper "On the Carboniferous Brachiopoda of Itaitúba, Rio Tapajos, Province of Pará, Brazil," by O. A. Derby, Bull. Cornell University, (Science), Vol. I, No. 2, where figures and descriptions are given.

‡ Hartt, Geology and Physical Geography of Brazil, 1870, p. 519.

of iron and manganese, to which the variegated colors are due, for which the rock is so much admired. The specific gravity, 2·9, shows that it is aragonite.

III. Botany and Zoology.

1. *Relation of Coloration to Environment.*—Mr. Wallace's oversight about a "*Pelargonium* of Kerguelen's Land," has been pointed out in *Nature* and noted in this Journal (p. 400). There is another oversight as to locality, which may as well be corrected, though of no practical consequence. It is in Florida, not "Virginia," that the white pigs are poisoned by Paint-root (*Lachnanthes*), while the black are unaffected. It may be, however, that Mr. Darwin's explanation of the immunity is nearer the mark than Dr. Ogle's, adopted by Mr. Wallace, plausible as the latter is. For if only black hogs are raised, as Prof. Wyman stated, and if the black pigs, by reason of better smell and taste do not eat the root, as Dr. Ogle suggests, what is it "which colored their bones pink?" It may not be so, but Prof. Wyman's account implies that the bones of the black hogs are thus colored. Will some one at the proper localities in Florida investigate this? A. G.

2. *Subradical solitary Flowers in Scirpus.*—The Rev. Thomas Morong, of Melrose, Massachusetts, recently brought me some specimens of my *Scirpus supinus*, var. *Hallii* (olim *S. Hallii*), which he gathered on the borders of Winter Pond in Woburn or Winchester, Massachusetts, late in September. Mr. Wm. Boott had also detected this plant in the same locality. It is interesting to know that this is a New England as well as a Western species. But a higher interest is given by Mr. Morong's discovery that this plant freely produces solitary female flowers in the axils of sheaths or short leaves at the base of the culm. These subradical flowers, apparently produced only at the close of summer, have capillary styles of half an inch to a full inch in length, mostly deeply three-cleft with unequal branches, sometimes three-parted or two-parted nearly to the ovary. The latter sometimes matures an akene which is similar to those of the spikes above. No stamens have been detected in these flowers; but they are found in some imperfect and four to five-flowered subradical spikes which I have occasionally met with, and which are in some sort intermediate between the ordinary and this extraordinary inflorescence. Mr. Morong noticed that the flowers in his specimens were triandrous; but I find that some are diandrous. These long-overlooked subradical flowers are now obvious in most of my herbarium specimens from Illinois, Missouri, and Texas, in those with trifid as well as those with bifid stigmas of the ordinary flowers. I find no trace of subradical flowers in the true *S. supinus* of the Old World, but my specimens are scanty. They occur, however, in a specimen (resembling our American plant) of Griffith's Bengal collection. This American variety, or species, has narrower spikelets and more carinate scales than is usual in *S. supinus*.

A. G.

3. *Dictionaire de Botanique;* par M. H. BAILLON. *Dessins* de A. FAGUET. Premier fascicule. (5 francs.) Paris: Librairie Hachette & Cie.—This is a large undertaking. The first fasciculus just issued consists of 80 pages, large 4to, double columns, with one chromolithic colored plate (of an *Æschynanthus*) and very many wood-cuts, some of which have done service in the editor's other works. To this we would not object, nor to the more profuse than pertinent illustration of the first article of the book, viz: a privative, by sixteen figures, five to explain its use in the word *acetylédone*, three for that of *asépale*, six for *apétale;* but we do object to the teaching that *Rubia*, *Loranthus* and *Thesium* are destitute of calyx, and that *Asparagus*, *Frittillaria* and *Galanthus* are apetalous. The work is almost exhaustive in plan, is beautifully illustrated, and well printed on excellent paper. The price therefore is low; for those who do not possess a botanical library it should be a boon; for those who do, a great convenience. It is far more needed than the *Histoire des Plantes*, and we are glad that Prof. Baillon has turned his labors in this direction. The list of collaborators already announced, and who have contributed to this fascicle contains good names, the more notable being those of De Seynes, Nylander, Fournier, Bureau, Weddel and Ascherson. Among them is the name of *Rafinesque!* Apparently all botanical names are to be given, the genera in French or Latin form, or in both, generic characters sketched, important genera illustrated, popular names explained or referred, botanical terms defined, and botanical authors biographically noticed. The physiological articles are encyclopœdic; that on *absorption* fills almost six of the large pages, *accroisement* four and a half. Accuracy in such a work is of the first importance, and we may presume that all reasonable pains will be taken. But we notice that, on p. 27, the akene of a Valerian, with its pappus, figures for that of a *composée*, and on p. 41, *Trautvetteria* is named *Actæa spicata*, and Agassiz is said to have died at New York. A. G.

4. *Nuovo Giornale Botanico Italiano* diretto du T. CARUEL. Pisa. Vol. viii. 1876.—This volume was issued in four parts, of unequal size, the first in January, the fourth in October; the journal is apparently well sustained; and, besides the editor's own articles, has papers by De Notaris, Delpino, Arcangeli, Saccardo, etc. A. G.

5. *Flora Orientalis . . . auctore* EDMOND BOISSIER.—The third volume of this important Flora—which failed to reach us seasonably—was published in 1875. It fills 1133 pages, and carries the work on from *Caprifoliaceæ* to *Pyrolaceæ* inclusive; the larger part being occupied by the *Compositæ*, which dominate in the Orient as they do in North America, but under different tribes, the *Inuleæ* and *Cynareæ* taking the lead. *Centaurea* has 182 species, *Cirsium* (*Cnicus*) 74, and *Cousinia* 136, almost all Asiatic. Before the close of 1875 the first part of the fourth volume was likewise issued (280 pages), continuing the *Gamopetalæ*, *Borragineæ* being the largest order. The remainder of this volume may soon be expected. A. G.

6. *On the Barringtoniaceæ*, by JOHN MIERS, F.R.S., etc.—An elaborate memoir of this group of tropical plants, published in the first volume of the new series of the Transactions of the Linnean Society, London, 1875, with nine plates. Mr. Miers insists upon the complete separation of these plants from *Myrtaceæ*, and their independence as a natural order, of ten genera, one of which is a restoration and four newly proposed. The typical genus is reduced to a single species, while the restored *Butonica* has sixteen, and *Stravadium* nineteen. It is interesting to see that a veteran of the author's age has the courage to undertake and the force to execute a work of this sort. The figures, moreover, are all by his hand. A. G.

7. *A Catalogue of the Forest Trees of the United States, which usually attain a height of sixteen feet or more, with notes and brief descriptions of the more important species, illustrating the collection of Forest-tree sections on exhibition by the Department of Agriculture at the Centennial Exhibition, Philadelphia.* Prepared by GEO. VASEY, M.D. (Washington, 1876. 38 pp. 8vo.)—All agree in awarding great credit to Dr. Vasey for the United States exhibition of our native trees and arborescent plants. Making the collection general and as far as possible complete, and stinted both in means and time, he could not undertake to accumulate sections of large trunks, such as those of some State and other exhibits; but his collection was full, systematic, well-displayed, and most instructive. This accompanying pamphlet, very useful in illustrating the exhibition, will still be convenient and valuable for reference. A. G.

8. *Morphology of the Carpellary Scales of Coniferæ.*—The true nature of the female flower of Coniferæ has been an important question among botanists since fifty years, when Robert Brown first announced the doctrine of their gymnospermous character. Without going into details of the history of investigations and theories, it may be stated at once that the very thorough treatment of the question by G. Stenzel, published a few months ago in the Nov. Act. Nat. Cur., vol. xxxviii, as reported by Prof. Eichler in Flora of September 1st, seems definitely to settle the controversy. The result of Stenzel's examination of numerous monstrosities of female flowers of the *Abies excelsa*, obtained at the limit of tree vegetation on the Sudetic Mountains, is that Mohl's view of the structure of the fruit-scale, based on the nature of the double leaf of Sciadopitys, is the correct one. The fruit-scale in *Abies*, and in all *Abietineæ*, in this view consists of two leaves of an undeveloped axis, or branchlet originating in the axil of the bract, and the posterior (superior) edges of these leaves being connate laterally and a little backward, as the lowest pair of leaves or bracts in Coniferæ always are, the leaves turn their back toward the axis of the inflorescence (the cone) and bear on that side one ovule each. In *Cupressineæ*, where the carpellary scale is peltate, and often bears numerous ovules, the same morphological explanation holds good, and even in *Podocarpeæ*

and *Taxineæ*, which have no fruit-scale, we must come to the same conclusion, assuming a virtual suppression of the scale. The greatest difficulty seems to arise from the position of the ovules on the dorsal side of the open carpel, which is not seen in any angiospermous plants; however, the anther-cells, which morphologically correspond to the ovules, are in Coniferæ also borne on the lower side of the stamen-scale; and for further analogy we have to look to the *Cycadeæ*, and, be it boldly announced, to the *Ferns*. *Lycopodiaceæ*, on the other hand, bearing the spore-cases on the upper side of the leaf, cannot be regarded as the progenitors of Coniferæ, as has been thought. The relationship of Coniferæ is with *Cycadeæ* and Ferns, while *Gnetaceæ* become still farther removed from them. The writer of this notice has seen monstrous (proliferous) cones of *Abies Engelmanni*, in Colorado, but only at the upper limit of tree-vegetation, under similar conditions to the European monstrosities. He has also noticed the foliaceous development of the carpellary scales in monstrosities of *Abies Canadensis*, either into a distinct or a more or less connate pair of leaves; but only at the base, not, as in other species, at the top of the cone. G. E.

9. *Species, Genera, et Ordines Algarum. Volumen Tertium: De Florideis Curæ Posteriores.* Auctore J. G. AGARDH. Lund. 1876.—In the present volume, the author reviews the species described in the first, second, and a portion of the third part of volume second of his classic work on algæ, giving frequent emendations, and interpolating the species described since the publication of that volume. The whole forms a volume of 700 pages, and, with the exception of the *Rhodomeleæ* and *Corallineæ*, purports to be a complete monograph of the orders of *Florideæ*. In the execution of the volume, the author has followed the same plan as in the preceding, and the text shows a careful editing, being comparatively free from typographical errors. Twenty species and two genera are either new to the United States or, for the first time, fully described. *Centroceras Oregonense* Ag., seems to be *Centroceras Eatonianum* Farlow, published in the Proc. Am. Acad., March 9, 1875. In the case of some of the species described from California, considering the small amount of material probably at his disposal, Agardh has been, perhaps, a little injudicious in separating as distinct species some forms which had been supposed to be identical with European species, as, for instance, *Sarcophyllis* (*Schizymenia*) *edulis*, taken to be the same as *S. edulis*, of Europe, and *Gymnogongyrus leptophyllus*, supposed to be *G. Griffithsiæ*. It is a well-known fact that species of algæ attain a larger size on the Californian coast than on European shores, and, in estimating whether a species is new, regard should be had to the difference of aspect produced by a more luxuriant growth. *Plocamium coccineum* illustrates this. In a collection of specimens of that species from all parts of the world, any experienced hand could readily pick out the specimens coming from California. Yet, although more luxuriant, no algologist, with the

exception of Kützing, would separate the Californian form as a distinct species. Should the Californian species of Agardh be accepted as genuine, it would go far to overturn the conclusion that, as in the case of phanerogams, so we have a number of species of algæ common to Europe and California, but wanting on the eastern coast of America. The significance of this view is familiar to the readers of this Journal from the writings of Professor Gray. The present volume, except for the preface and occasional footnotes, might be called a worthy sequel to those which have preceded. But in the preface, Agardh not only denies the fertilizing action of the antherozoids of the *Florideæ*, but even declares that he has not been able to see in the trichogyne anything more than an aborted branch. He completely ignores the brilliant discovery of Thuret and Bornet, and seems to think that the bare announcement that he does not believe it, ought to counterbalance the statements of careful observers. It may be that the neatly dried specimens on the herbarium shelves at Lund do not show clearly the nature of the trichogyne, but the correctness of Thuret's and Bornet's observations have been confirmed by numbers of algologists on the sea shore, and the fertilization of the more simple genera such as *Neuralion*, *Batrachospermum*, *Callithamnion*, etc., has become a common object of class-demonstration in the laboratories of Europe, and at least of one in this country. W. G. F.

10. *Notes Algologiques.* Fascicule I. Par M. M. Ed. Bornet et G. Thuret. Paris, 1876. Small folio.—This is the first portion of a work intended to embody the results of the observations of the late M. Thuret and Dr. Bornet for a long series of years. M. Thuret, during his frequent algological excursions, had a number of elaborate drawings executed, principally by Riocreux, with the intention of publishing them; but, owing to the difficulty of procuring capable engravers, the plan was abandoned. Not, however, wholly relinquishing his plan, he had many less complicated drawings prepared, which, on his untimely death in the spring of 1875, were bequeathed to his friend and co-worker, Dr. Bornet, who was to superintend their publication. The plates of this fascicule are twenty-five in number and, in point of execution, are unequalled by any relating to algæ, excepting those which illustrated Thuret's articles on zoöspores and antheridia in the *Annales.* The work is to algology what the *Carpologia Fungorum Selecta* of the Tulasne Brothers is to fungology. The text is no less rich and complete than the plates. A general description of the reproduction and reproductive organs of different genera precedes the detailed description of the plates, which, in the present fascicule, represent species referred to by Bornet in his *Deuxième Note sur les Gonidies des Lichens*, or which were collected by Schousboe in Morocco and determined by Thuret. The notes are a masterly exposition of the reproduction in the *Nostochineæ* and *Florideæ*, and are so replete with facts that a single reading barely suffices to give a general notion of the contents. Particularly interesting are the description of the reproduction of *Calothrix confervicola*,

and the comparative description of the fruit of the different genera included by older writers under *Callithamnion*. The fertilization of *Polyides*, similar to *Dudresnaya*, is referred to, but will probably be figured later. The work of Agardh is an encyclopædia in which one may find the name of any *Floridiæ* more easily perhaps than in any other. The work of Bornet and Thuret has a different object. Determination of names by a somewhat artificial grouping is subordinated to a true knowledge of the relations of algæ through a study of their minute anatomy and development.

W. G. F.

11. *Nuttall Ornithological Club.*—Bulletin No. 3, for September, contains, besides various miscellaneous notes, a paper by J. A. Allen on the Decrease of Birds in Massachusetts, one by Dr. Elliott Coues on the number of Primaries in Oscines, and one by William Brewster on the Yellow-bellied Woodpecker, *Sphyrapicus varius*.

12. *A Course of Practical Instruction in Elementary Biology*, by T. H. Huxley and H. N. Martin. Second edition, revised. 280 pp. 8vo. London and New York. 1876. (Macmillan & Co.)

13. *On Casting the skin in Menopoma Alleghaniense;* by A. R. Grote. The following observation has been recently made by Mr. Grote on a specimen in the aquarium of the Buffalo Society of Natural Sciences. The wide mouth is opened several times to its fullest extent, by which means the skin is parted on the lips, and then rolls backward over the head. Before this, the transparent pellicle was observed to be loosely surrounding the surface of the animal from which it had separated. By short jerky movements the *Menopoma* then withdrew its front legs from the old skin. The animal next moved in a forward direction, withdrawing itself from the skin, which was shoved back by the water until the skin was folded against the hind legs. The *Menopoma* then turned shortly round on itself, and, taking the skin in its mouth, drew it over the hind legs and tail. The skin was retained in the mouth and subsequently swallowed. The whole operation was quickly performed.

IV. Astronomy.

1. *Intra-Mercurial Planet.*—In his discussion of the theory of Mercury, Mr. Le Verrier found reason to believe in the existence of a planet, or of matter enough to form a planet, revolving around the sun within the orbit of Mercury. An observation of Mr. Weber, of Peckeloh, of a black round spot seen by him last April upon the sun, has revived the question, though Weber is proved, by observations at Madrid and Greenwich, to have seen only an ordinary sun-spot.

From nearly thirty observations within the last 115 years of spots supposed to have been such a planet, Mr. Le Verrier selects ten as most worthy of confidence, because the spot is reported to have been in motion. Of these, five are in March and October,

and they are fairly represented by a planet revolving in an orbit either in 33·02 or in 27·96 days; less exactly by an orbit of 24·25 days, or one of 40·32 days.

At Mr. Le Verrier's request the sun was observed early in October, both in this country and in Europe, but without result. He thinks a transit possible on the 22d of March next, if the orbit is one of 33·02 days. No other spring transit occurs with that supposition before 1885. For an October transit we must wait till about 1881. None of the observations made use of by Le Verrier, however, appear to be so free from doubts as to establish the existence of a planet within the orbit of Mercury. H. A. N.

2. *November Meteors.*—On the morning of November 14th, between twelve and one o'clock, the sky at New Haven was partly clear. Out of about twelve meteors seen, three might be called conformable to the radiant in Leo. Shortly after one o'clock the sky became wholly overcast. H. A. N.

IV. Miscellaneous Scientific Intelligence.

1. *On the Extirpation of Species;* by Prof. Alfred Newton. (From his Address, Brit. Assoc., as published in Nature of Sept. 14.)—And now to follow out the idea with which I began. Having touched on the two chief zoological events of the year, let us see if they do not suggest something that will not be beneath your consideration for the remainder of this address. I have spoken of the certainty of the expedition from which we now welcome our friends being succeeded by others of similar character. We shall hardly be indulging any vain imagination if we ask ourselves what we may look forward to as regards their reports; and to one point we may perhaps usefully apply ourselves.

What if a future *Challenger* shall report of some island, now known to possess a rich and varied animal population, that its present fauna had disappeared? that its only mammals were feral pigs, goats, rats, and rabbits—with an infusion of ferrets, introduced by a zealous "acclimatizer" to check the seperabundance of the rodents last-named, but contented themselves with the colonists' chickens? that sparrows and starlings, brought from Europe, were its only land-birds, that the former had propagated to such an extent that the cultivation of cereals had ceased to pay—the prohibition of bird-keeping boys by the local school-board contributing to the same effect—and that the latter (the starlings) having put an end to the indigenous insectivorous birds by consuming their food, had turned their attention to the settlers' orchards, so that a crop of fruit was only to be looked for about once in five years—when the great periodical cyclones had reduced the number of the depredators? that the goats had destroyed one half of the original flora, and the rabbits the rest? that the pigs devastated the potato-gardens, and yam-grounds? This is no fanciful picture. I pretend not to the gift of prophecy; that is a faculty alien to the scientific mind; but if we may reason from the

known to the unknown, from what has been and from what is to what will be, I cannot entertain a doubt that these things are coming to pass; for I am sure there are places where what is very like them has already happened.

You may ask why this is so? why do these lands so speedily succumb to the strangers from beyond the sea? One part of the answer is ready to hand with those who have learned one of the first principles of biology which our great master, Mr. Darwin, has laid down for us. The weaker, the more generalized forms of life must always make way for the stronger and more specialized. The other part of the answer is supplied by Mr. Wallace; for no one can have studied his volumes to much purpose without perceiving that the inhabitants of oceanic islands and of the southern hemisphere—the great Australian Region especially, and South America not much less, are the direct and comparatively speaking little-changed descendants of an older, a more generalized and a weaker fauna than are the present inhabitants of this quarter of the globe, which have been, so to speak, elaborated by nature and turned out as the latest and most perfect samples of her handiwork.

Set face to face with unlooked-for invaders, and forced into a contest with them from which there is no retreat, it is not in the least surprising that the natives should succumb. They have hitherto had to struggle for existence only with creatures of a like organization; and the issue of the contest which has been going on for ages is that, adapted to the condition under which they find themselves, they maintain their footing on the grounds of equality among one another, and so for centuries they may have "kept the noiseless tenor of their way." Suddenly man interferes and lets loose upon them an entirely new race of animals, which act and react in a thousand different fashions on their circumstances. It is not necessary that the new comers should be predacious; they may be so far void of offence as to abstain from assaulting the aboriginal population; but they occupy the same haunts and consume the same food. The fruit, the herbage, and other supplies that sufficed to support the ancient fauna now have to furnish forage for the invaders as well. Their effects on the flora there is no need for me to trace, since Dr. Hooker expressly made them one of the themes of that discourse to which many of us listened with rapt attention a few years since at this Association. But the consequences of the invasion to the native fauna have never been so fully made known. The new comers are creatures whose organization has been prepared by and for combat throughout generations innumerable. Their ancestors have been elevated in the scale of being by the discipline of strife. Their descendants inherit the developed qualities that enabled those ancestors to win a hard-fought existence when the animals around them were no higher in grade than those among which the descendants are now thrown. Can we doubt that the victory inclines to the heirs of the ancient conquerors? The struggle is like one between an army of veterans

and a population unused to warfare. It is that of Spaniards with matchlocks and coats of mail against Aztecs with feather cloaks and bows and arrows. *Mala salus victis.* A few years, and the majority of native species are exterminated. But this is not the worst. The species which perish most quickly are just those that naturalists would most wish to preserve; for they are those peculiar and endemic forms that in structure and constitution represent the ancient state of things upon the earth, and supply us with some of the most instructive evidence as to the order of nature.

With the progress of civilization it is plain that there will soon be hardly a land but will bear the standard of a European nation or of a community of European descent, and, as things are going on, be overrun by their imports. If this were inevitable, it would be useless to complain. But is it inevitable? Is it not obvious that most of this extermination is being carried on unwittingly, and may not some of it be avoided by proper precautions? If so, should not men of science make a stand, and interest the ignorant or careless in the importance of the subject? I cannot divest myself of the belief that the course of the next century will see the extirpation, not only of most of the peculiar faunas I had in view a few minutes ago, but of a great multitude of other species of animals throughout all parts of the world. The regret with which I regard such extirpation is not merely a matter of sentiment. Here sentiment and science are for once on the same side. A heavy blow will be inflicted on zoology by the disappearance of some of these marvellous and peculiar forms. There is no one species of animal whose structure and habits have been so completely investigated that absence of the means of further examination would not be a distinct deprivation to science; and as what Science has done is only an earnest of what she will do, we cannot say that the time shall ever come when the want of those means will not be severely felt. It is then for scientific men, and for naturalists especially, to consider whether they are not bound, in the interest of their successors, to interpose more than they have hitherto given any signs of doing.

But outside this audience there are many who care little for consequences like these. Such persons may, however, be impressed by thinking that the indiscriminate destruction of animals which, in one way or another, is now going on, must sooner or later lead to the extirpation of many of those which minister to our wants, whether of comfort or luxury. The fur-bearing creatures will speedily, if they do not already, require some protection to be generally accorded to them; and that such protection can be effectually given is evident if we take the trouble of inquiring as to the steps taken by the Russian local authorities in Alaska, and now, I believe, continued by those of the United States, for limiting the slaughter of the sea-otter and the fur-seals of the adjacent islands to particular seasons. No one can suppose that, even with the assistance we get from Siberia, our supply of ivory will con-

tinue what it now is when the interior of Africa is pacified and settled, as we can hardly doubt that it one day will be; and unless we can find some substitute for that useful substance before that day comes, it would be only prudent to do something to check the wasteful destruction of elephants. Many people may think that the continent of Africa is too vast, and its animal life too luxuriant, for the efforts of man materially to affect it. If we inquire, however, we shall find that this is not the case, and that there is an enormous tract of country, extending far beyond our colonies and the territories of the neighboring republics, from which most of the larger mammals have already disappeared. There is good reason to believe that at least one species has become extinct within the last five-and-twenty years or thereabouts; and though I do not mean to say that this species, the true zebra, had any economic value, yet its fate is an indication of what will befall its fellows; while to the zoologist its extirpation is a matter of moment, being probably the first case of the total extinction of a large terrestrial mammal since the remote days when the *Megaceros hibernicus* disappeared.

Time would fail me if I attempted to go into particulars with regard to the marine *Mammalia.* It is notorious that various members of the orders *Sirenia*, *Cetacea*, and *Pinnipedia*, have recently dwindled in numbers or altogether vanished from the earth. The manatee and dugong have been recklessly killed off from hundreds of localities where but a century or so since they abounded; and with them the stores of valuable oil that they furnish have been lost. That very remarkable Sirenian, the huge *Rhytina gigas* has become utterly extinct. The greed of whalers is believed to have had the same effect on a Cetacean (the *Balæna biscayensis*) which was once the cause of a flourishing industry on the coasts of France and Spain. The same greed has almost exterminated the right-whale of the northern seas, and is fast accomplishing the same end in the case of seals all over the world. You are probably aware that an Act of Parliament, passed in the session of 1875, was intended to put some check upon those bloody massacres that anually take place on the floating ice of the North Atlantic, to which these creatures resort at the time of bringing forth their young, when

"Sires, mothers, children in one carnage lie."

But, whether through official indifference, or what, I know not, the treaties with foreign nations authorized by that Act were not completed; and last spring, at the solicitation of certain Aberdeen or Peterhead shipowners, the Board of Trade allowed "one year more" of wholesale slaughter. Whatever other nations might like to do, our hands at least should have been unstained. It is admitted that in certain manufactures—that of jute, for instance—animal oil is absolutely necessary. It is easy to see that before long there will be very little animal oil forthcoming.

2. *List of papers read at the session of the National Academy of Sciences held at Philadelphia, Pa., October 17th, 18th, and 19th,* 1876.—

Contributions to Meteorology, by ELIAS LOOMIS.

Upon the direct comparison of Solar radiation with that of the Bessemer Furnace, and upon the law of Dulong and Petit, by S. P. LANGLEY.

On the affinities of Hypocephalus, by J. L. LECONTE.

On a change in the relative length of the British Bronze and Iron Standard Yards in the U. S. Office of Weights and Measures, by J. E. HILGARD.

On sound in relation to Fog Signals, by JOSEPH HENRY.

The Results of an Investigation upon the Transformations of Planorbis multiformis, by ALPHEUS HYATT.

On the transmission of the shock of the explosion at Hell Gate, by H. L. ABBOT.

On the geological structure and topographical aspects of the Catskill Mountains, by JAMES HALL.

On the physical structure and altitudes of the Southern groups of the Catskill Mountains, by A. GUYOT.

On the force involved in Crookes' Radiometer, by O. N. ROOD.

On a new method of studying the reflexion of sound waves, by O. N. ROOD.

On a property of the Retina first observed by Tait, by O. N. ROOD.

On a series of molecular changes in the basaltic rocks of Lake Superior, by R. PUMPELLY.

On the power of certain substances to abstract salts from their solution in water by filtration through them, by R. E. ROGERS.

Note on the new compensation of a pendulum heretofore described, by J. LAWRENCE SMITH.

The following is a list of the members elected at this session: G. F. Barker, Philadelphia, Pa.; Joel Asaph Allen, Cambridge, Mass.; William M. Gabb, Philadelphia, Pa.; E. S. Morse, Salem, Mass.; John Newton, U. S. Army.

3. *Proceedings of the Cincinnati Society of Natural History.*—No. 1 of these Proceedings, "January, 1876," has been recently published. Its twelve pages are occupied by a valuable paper on the Variation in form of the Family Strepomatidæ, with descriptions of new species, by A. G. Wetherby, which is illustrated by a plate of fifteen figures representing the new species, *Lithasia plicata*, *Angitrema parva*, *Goniobasis plicato-striata*, *Anculosa umbilicata*, *Angitrema angulata.*

4. *The Scientific Monthly, a Magazine devoted to the Natural Sciences.* E. H. FITCH, editor and proprietor, Toledo, Ohio.—The August number of this monthly, No. 11 of the first volume, contains various papers of popular interest. The first, by Dr. T. A. Fitch, continues an article on Springs, which is illustrated by a plate giving a view of a mud volcano.

5. *The Universal Metric System*, by ANDREW COLIN, M. E., Principal of a Preparatory Scientific School. 50 pp. 12mo. New York, 1876. (D. Appleton & Co.)—This little work was prepared, as the author states, "especially for candidates for schools of science, engineers and others;" and it is well adapted for its purpose, and for the wider one of fitting all students of the higher schools or academies of the country for the easy use of the metric system in calculations. The expression universal is applied to the system because, although first adopted by the French, "almost all the nations of the world have now adopted it," and its use will undoubtedly be soon actually universal. The explanations of the subject are simple and precise; and numerous problems are given, occupying eighteen pages, in order to make the work a good class-book.

6. *Bulletin of the Minnesota Academy of Natural Sciences, for the year* 1875. 44 pp. 8vo.—This Bulletin contains a paper by Prof. N. H. WINCHELL on early explorers of the Minnesota valley (continued); a report on Ornithology by Dr. F. L. HATCH; notes on Entomology, by R. J. MENDENHALL, treating of some noxious insects; notes on a storm on the 18th of July, 1867, over Pope and Douglass counties, Minnesota, by G. B. WRIGHT, the rainfall of which, in Sauk Centre, amounted to at least "30 inches and probably reached 36 inches;" meteorological statistics, by WILLIAM CHENEY; and notes on a deep well drilled at East Minneapolis; by N. H. WINCHELL. The depth of this well was 1421 feet, and it descended, after passing the surface soil, through the Trenton limestone and subjacent strata, to a clayey sandstone of the Primordial—the formation that affords the well known "pipestone" or *catlinite*, of Minnesota.

7. *Arrangements for a Meeting of the British Association—an example worth following.*—When the British Association met at Belfast (we cite from the Athenæum for Sept. 9), an excellent guide-book was prepared for the occasion and presented to members of Committees. In 1875, the promoters of the Bristol meeting, following up the experiment, brought out a larger and more elaborate hand-book. This year, at Glasgow, the scheme was further extended, and on Wednesday morning the members were surprised by the issue of a work in three volumes, one describing the geology of the district, another its fauna and flora, and the third its manufactures. Moreover several scientific collections were specially got up in view of the meeting, and nearly a hundred factories were thrown open for inspection. Besides, there were popular evening lectures outside of the work of the Association: on Monday evening, by Sir Wyville Thomson on the Challenger Expedition, on Tuesday evening, by Commander Cameron on his African explorations, and Saturday evening, by the same, to the workingmen of Glasgow. In addition, the excursions while of various kinds, were mainly for scientific purposes.

The following works were received too late to be here noticed:

Reports on the Geological Survey of Pennsylvania, by J. J. Stevenson and Professor Frazer, Jr.

Zoology of Lieut. Wheeler's Expedition. 1020 pp. 4to. with many plates, part of them colored.

The American Bisons, living and extinct, by J. A. Allen. 246 pp. 4to, with 12 plates. Memoirs of the Mus. Compar. Zool., Cambridge, Mass.

Monograph of American Trilobites, Part I; by A. Vogdes, U. S. A. 16 pp. Tampa, Florida. 1876.

OBITUARY.

CHARLES SAINTE-CLAIRE DEVILLE, the distinguished geologist and meteorologist, died on the 10th of October, aged 62 years. He was, at the time of his death, Inspector-General of the French Meteorological Stations. A notice in *Nature*, speaks of his singular modesty, and states that "in accordance with a desire expressed in his will, no official deputation of the Academy was present at his funeral, and no funeral oration was pronounced over his grave."

APPENDIX.

ART. L.—*Principal Characters of American Pterodactyls;** by Professor O. C. MARSH.

THE remains of *Pterosauria*, or flying lizards, hitherto found in this country, are all from the Upper Cretaceous deposits of Kansas. They are remarkable for their large size, some having a spread of wings not less than twenty-five feet. They differ widely from the Pterodactyls of the old world, especially in the *absence of teeth*, and hence have been placed by the writer in a new order, *Pteranodontia*,† from the typical genus *Pteranodon*.

In this genus, the skull is much elongated. The orbits, and the antorbital and nasal apertures are large. The maxillary and premaxillary bones are coossified, and entirely edentulous. The atlas and axis are united. The scapular arch presents some peculiar features, not before known in any vertebrate. The scapula, which is firmly coossified with the coracoid, has at its distal end an oblique articular face. This articulation is separated from the corresponding facet of the opposite scapula by a thin median plate, which is apparently a neural spine of a dorsal vertebra. The two scapulæ thus brace each other, and aid in securing powerful flight. In *Pteranodon* the fourth finger is greatly elongated, and the wing metacarpal is longer than half the antebrachium, There are five separate carpal bones, beside the pteroid bone which supported the membrane. The pteroid is not a true carpal, but is perhaps homologous with the small bone in the foot of a bat which supports the patagium. The first three metacarpals are very slender, pointed above, and do not reach the carpus. At their distal end they supported sharp, curved claws. In some species, the distal phalanx of the wing finger is not straight, but falciform.

The pelvis in *Pteranodon* is of moderate size. The ilia are elongate, and the acetabulum is imperforate. The ischia are broad, and united on the median line. The tail is short and slender, and the distal caudals are sometimes coossified. The posterior limbs are well developed. The tibia has at its distal end a pulley-like articular surface. There are two tarsal bones of

* Abstract of a paper read before the American Association for the Advancement of Science, at Buffalo, Aug. 28th, 1876.

† This Journal, vol. xi, p. 507, June, 1876.

nearly equal size, and a small lateral bone, which may possibly be the distal end of the fibula. There are four metatarsals of nearly the same length, and their ungual phalanges are pointed, but not much curved.

The known species of *Pteranodon* are as follows: *Pteranodon occidentalis* Marsh (*Ornithochirus harpyia* Cope), *Pteranodon ingens* Marsh (*Ornithochirus umbrosus* Cope), *Pteranodon velox* Marsh, *Pteranodon longiceps* Marsh, and *Pteranodon comptus* Marsh.

Nyctosaurus, gen. nov.

A second genus of American Pterodactyls is represented in the Yale Museum by several well preserved specimens. This genus is nearly related to *Pteranodon*, but may be readily distinguished from it by the scapular arch, in which the coracoid is not coossified with the scapula. The latter bone, moreover, has no articulation at its distal end, which is comparatively thin and expanded. The type of this genus is *Pteranodon gracilis* Marsh, which may now be called *Nyctosaurus gracilis*. It was a Pterodactyl of medium size, measuring about eight to ten feet between the tips of the expanded wings. Its locality is in the upper Cretaceous of Western Kansas. The type specimens of all the above species are preserved in the Museum of Yale College.

INDEX TO VOLUME XII.*

* The Index contains the general heads BOTANY, GEOLOGY, MINERALOGY, ZOOLOGY, and under each the titles of Articles referring thereto are collected.

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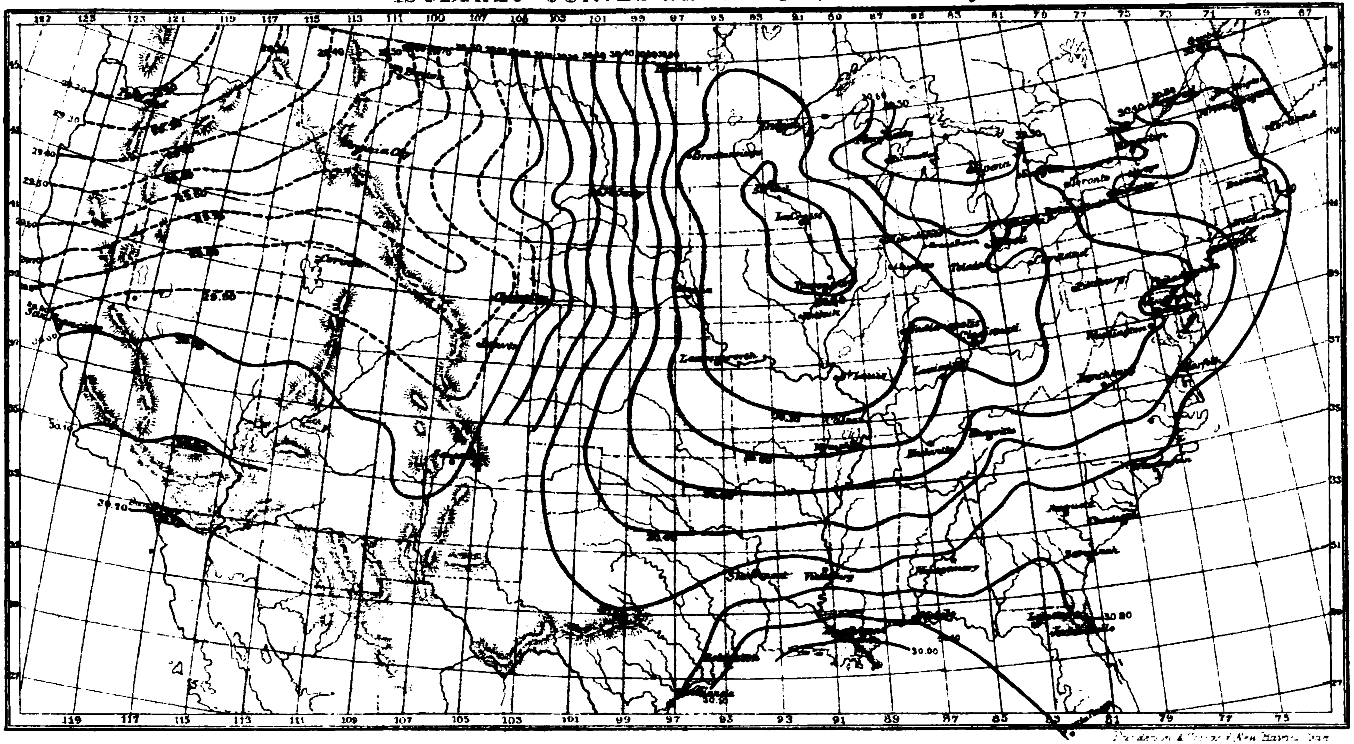
PLATE I

ISOBARIC CURVES DEC 24 1872, 7.35 A.M.



THERMIC ISABNORMALS DEC 24 1872 7.35 AM

PLATE II

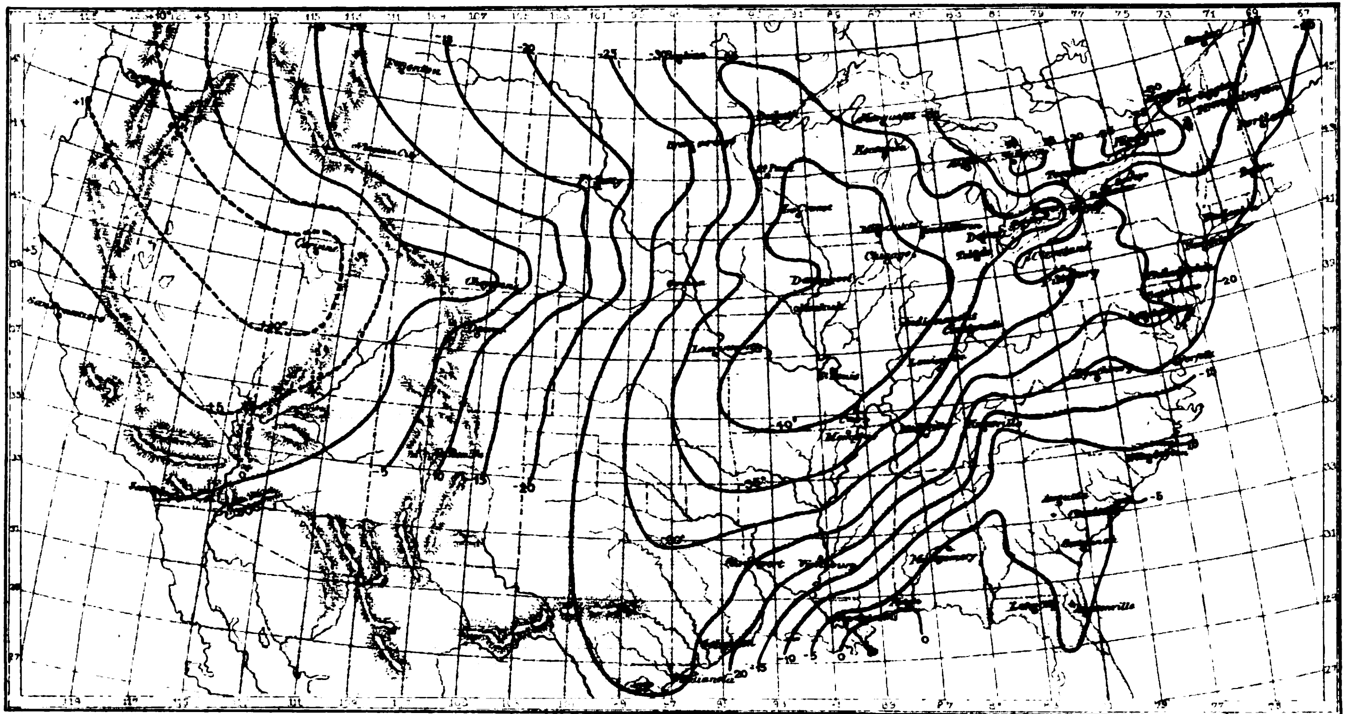
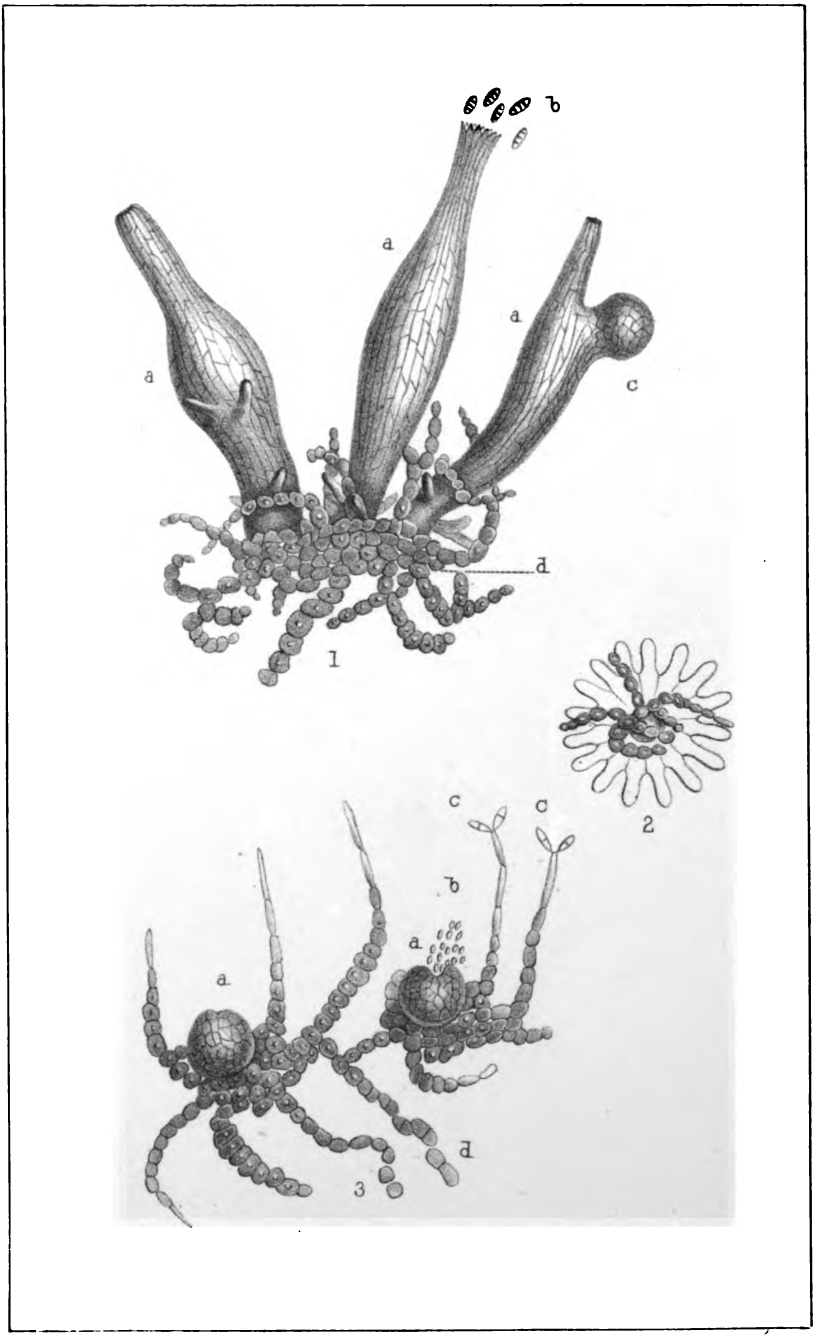
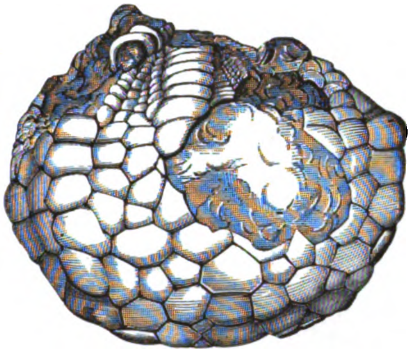


PLATE III.



T. Sinclair & son, lith. Phila

1.



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× 2.

2b.

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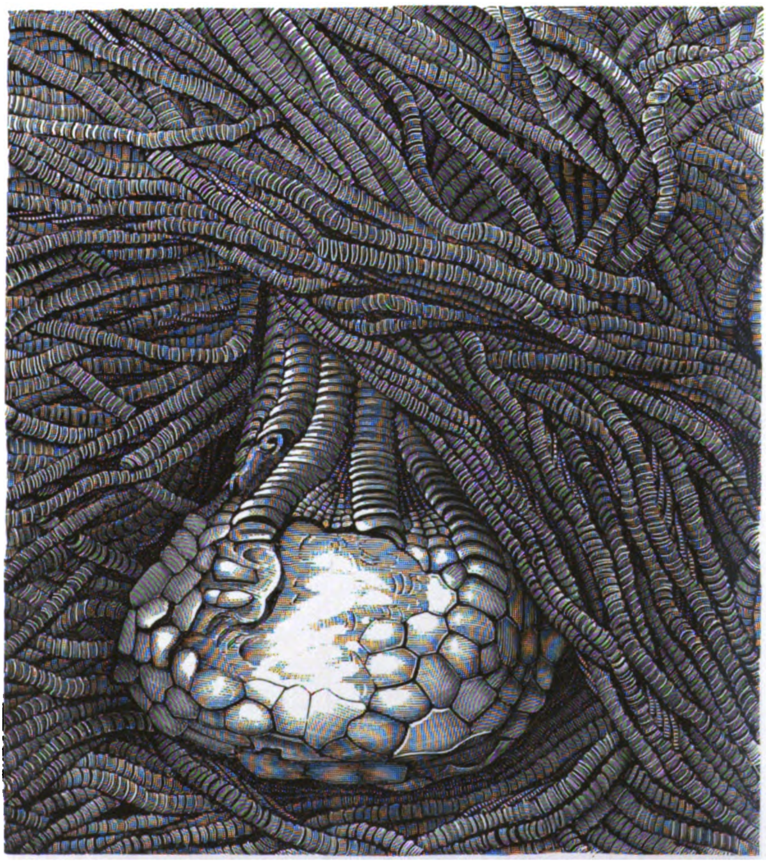


UINTACRINUS SOCIALIS. Grinnell.

Fig. 1

Fig. 2

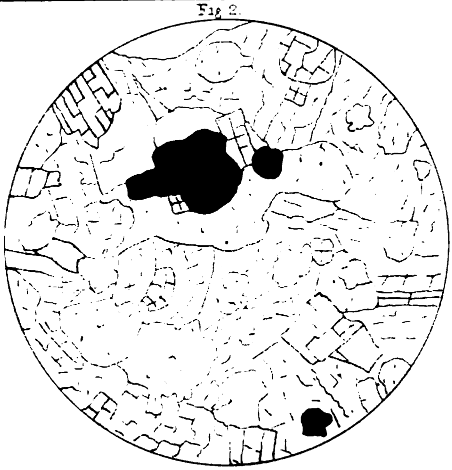


Fig. 3

Fig. 4

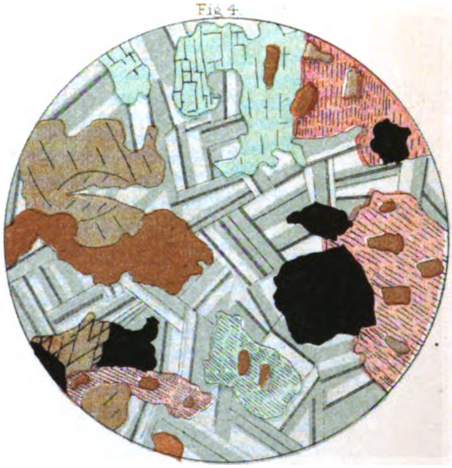


Fig. 5

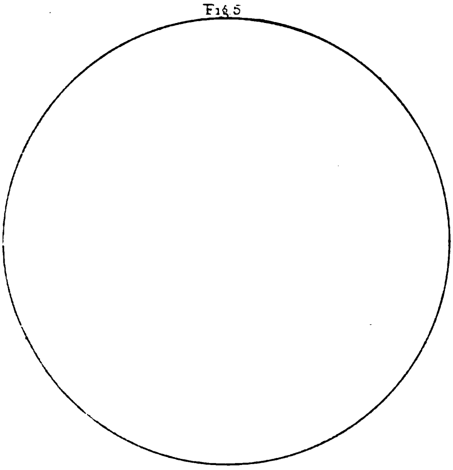
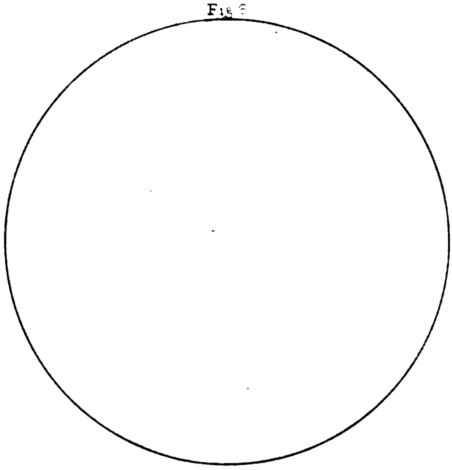


Fig. 6



Drawn from nature by G. W. Hawes

Punderson & Crisand New Haven, Ct.